FACTORS AFFECTING THE DIETARY MAINTENANCE LEVEL OF GERIATRIC HORSES

By

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Abstract

The geriatric horse has a tendency to either be obese with a body score around nine or undernourished with a body score around two. Nutrition, exercise, and the medical condition of the horse all contribute to the body score of the horse. Although nutrition is a major factor to the weight of the horse, research has revealed exercise will help the horse to glean more of the nutrients in their food and be able to utilize them more efficiently in their muscles. Exercise will also prevent some of the medical conditions common in older horses.

The Digestive System

The digestive system uses physical and chemical means to break down ingested food as a means to provide the body with nutrients. The equine digestive system begins in the mouth. The horse begins to mechanically breakdown the food it has digested through chewing. This is also known as mastication. Saliva will wet the masticated food and will form a bolus. The bolus is swallowed and will travel through the esophagus. The amount of saliva secreted will depend on the amount of forage the horse is ingesting. The more forage the horse consumes will cause the horse to secrete more saliva. After the bolus passes through the esophagus, the bolus enters the stomach. Hydrochloric acid secreted from goblet cells continues to break down the food. Hydrochloric acid also activates pepsin to form pepsinogen. Pepsinogen will start to break down protein in the stomach. After the stomach, the contents move into the small intestine. This is the main area where the carbohydrates are broken down and absorbed. Other products such as vitamins and minerals are also absorbed in the small intestine. The liver aids digestion by excreting bile salts into the small intestine. These bile salts mix with the fat to begin the digestion of lipids. Lipase finishes the digestion of lipids so the fat can be absorbed for use as energy. After the small intestine, it moves into the cecum with the help of the muscles surrounding the digestive system. The muscles move in a wave type of contraction known as peristalsis. The cecum is the horse's fermentation vat containing enzymes which break down the insoluble carbohydrates like cellulose. The products of these enzymes include all of the B vitamins, vitamin K, methane, butyrate, proprionate, acetate, and microbial protein. The remainder of the bolus moves into the large intestine where the water is reabsorbed to make the product as dry as possible. Once all of the water is reabsorbed, the rest is considered waste and is excreted as feces (Schurg, 2011).

The amount of exercise the animal completes daily will cause an increase in the amount of food they will need to consume. However, this increase will specifically help the horse by increasing the amount of digestible energy and the amount of protein. The increase of digestible energy will prevent any weight loss incurred by the increased exercise regimen. The increase in protein will aid the muscle grow and help repair the damage caused by daily exercise. A horse completing light exercise should be fed one and seven tenths to two percent of the horse's body weight to increase the diet by four Mcal per day of digestible energy and ten percent crude protein. A horse with a medium exercise load should be fed two to two and a quarter percent of the horse's body weight. This will increase the digestible energy by eight Mcal per day and ten and one-half percent crude protein. Lastly, the horse with an intense work load should be fed two and a quarter to two and one-half percent of the horse's body weight, which will increase by sixteen Mcal per day and the percent of crude protein to eleven percent of the diet. However, these dietary needs may need to be adjusted for individual horses depending on their individual needs. A good measurement to determine this would be the body condition score on the horse since weight loss is the number one symptom of deficient available energy (Schurg, 2012).

Nutrition

The geriatric horse is considered a horse of twenty years or older. The goal of the geriatric horse diet is to keep the body condition score between four and six. In some older horses, the diet does not need to be altered because the horse's digestive system is still efficient enough to break down and absorb the necessary nutrients. Other geriatric horses who need additional help for maintenance will need an altered diet to get their necessary nutrients. The diet will require an infusion of extra protein. The diet may also need to be supplemented with extra phosphorus, but not calcium. Calcium absorption will remain the same. Lastly, the fiber source

will need to be altered or be decreased to accomplish the breakdown of the cellulose in the hindgut. If fat deposition is still an issue with a geriatric horse after these changes have been made, adding a small amount of fat such as vegetable oil over a period of time will help to increase the caloric density of the diet. This allows the animals to take the energy they need from the diet rather than the fat and glycogen stores the horse had built up at other times. However, there are also other issues the geriatric horse can have such as hepatic or renal issues. The health issues of the geriatric horse should be considered when a diet is being formulated to help manage these conditions because they cannot be ignored (Pugh, 2002, 21-22). The overall motility of the system will affect the efficiency of the system. Over time, the peristaltic motion created by the muscles surrounding the system will get weaker. The bolus will take more time to move through the system. Peristalsis is also responsible for aiding in the mechanical breakdown of food. Weak peristaltic motion may result in the incomplete digestion of the food in the intestine (Schurg, 2012).

The goal of the geriatric horse's diet is to provide the horse with the nutrients they need to live as long and as happy a life as possible. When improper nutrition of the aged horse occurs, the diet will exacerbate any underlying conditions the horse may have developed. For example, a geriatric horse with hepatic problems will have trouble digesting fats because the liver will not be able to produce as much bile to aid in the breakdown of the fat. If the fat cannot be broken down, the small intestine cannot absorb the fats. Although improper feeding will exacerbate conditions such as this, the end result of any improper nutrition will cause weight loss in the geriatric horse (Pugh, 2002, 21-22). Improper nutrition could also result in obesity or a body score of ten. Obesity most commonly occurs by an excess ingestion of food and a minimal amount of exercise. There is also an increasing occurrence of insulin resistance occurring in this

older population. Insulin resistance can occur because the horse is obese. However, insulin resistance can also cause the horse to become obese (MyEquineClinic.com, n.d.).

Medical Conditions

A common medical issue in horses is colic which is a term for stomach pain. This pain is caused by one of four causes. The first type of colic is an excessive stretching of the intestinal wall due to impaction, gas buildup, or fluid buildup. The second is an excessive pressure on the mesentery fold which holds up the jejunum and ileum in the body cavity. The third cause is ischemia or lack of blood flow due to a twisted segment of intestine. Lastly, colic can occur due to inflammation of the intestine or peritoneum (Merck & Co., Inc., n.d.).

An initial incidence of colic becomes a high incidence condition for horses of any age causing a welfare concern for these horses. These horses will have an increased risk of recurring colic. However, the risk of recurrent colic episodes is increased by dental problems. These dental problems could be a result of cribbing where the horse is sucking wind against an object through an arched neck, but could be caused by another cause (C.E. Scantlebury, 2011). Geriatric horses have a lower probability of surviving the first incidence of colic. Therefore, owners should worry about helping the geriatric horse survive the first episode of colic instead of the recurring episodes of colic the horse could experience if the horse survives (Southwood, 2010).

Cushing's disease, also known as hyperadrenocorticism, usually occurs in older horses. Cushing's disease is the result of a benign tissue enlargement of the pituitary gland. The enlargement causes an excessive production of the hormone adrenocorticotropic hormone or ACTH which stimulates the secretion of hormones from the adrenal cortex (Merck & Co., Inc., n.d.). As a result of the hormonal imbalances of Cushing's disease, many side effects can result including insulin resistance and laminitis. When feeding a horse with Cushing's disease, the

insulin resistance or laminitis which could result causes diet changes which will help to quiet and reverse these secondary diseases (Harman, 2001).

Cushing's based laminitis requires a diet with high fiber and low carbohydrate composition to prevent further damage to the laminae by reducing the possible endotoxin absorption. Coenzyme Q10 and vitamin C are excellent antioxidants to reverse the effects of laminitis. Coenzyme Q10 stabilizes the mitochondrial membranes, inhibits the arachidonic acid pathway, and inhibits the formation of inflammatory prostaglandins, which will aid in pain relief. While vitamin C will boost the immune system, vitamin C will also regulate the phagocytic process triggered due to endotoxin shock by reducing the amount of free radicals produced. Laminitic horses have also shown they will consume more minerals than healthy horses. Methyl sulfonyl methane or MSM will help the laminae reconnect to the hoof wall. The MSM will provide organic sulfur for the disulfide bonds which connect the healthy laminae to the hoof wall. For those horses who develop diabetes and insulin resistance, they will require low sugar diets to prevent sugar spikes and lows. Multiple vitamins aid in easing the difficulties of diabetes. Magnesium allows the cell to be more flexible and permeable to insulin so the cell is able to absorb the insulin. Once in the cell, magnesium will influence insulin's actions. Chromium will increase the cell's sensitivity to both insulin binding and glucose uptake. Lastly, vanadium, also known as vanadyl sulfate, produces insulin-like effects during glucose metabolism by aiding the transport of glucose molecules into the cell. The last element to help the cell wall's sensitivity to insulin is essential fatty acids. Omega-3 fatty acid is usually deficient in the horse diet because most feeds utilize omega-6 fatty acids (Harman, 2001). Besides providing insulin sensitivity, omega-3 has anti-inflammatory properties to aid in other possible side effects of Cushing's such as laminitis (Schurg, 2012).

Diabetes mellitus or diabetes is the low or absent production of insulin from the beta islet cells in the pancreas. The abnormal production of insulin is a direct result of the destruction or damage of the islet cells (Merck & Co., Inc., n.d.). Although diabetes mellitus does require a change in their diet, the optimal diet is unknown. A low glycemic diet is suggested. This type of diet consists of a high fiber content, low concentrated sweets or simple sugars, and fat as a form of additional calories. Diabetes is uncommon in all horses and those horses who have damaged the islet cells do not live long lives due to the inability of the owner to help the horse regulate the disease. The most common occurrences of diabetes mellitus are found in foals while only a few occurrences have been seen in older horses (Johnson, 2012).

Insulin resistance is considered a form of diabetes, but is not the same as diabetes mellitus. Insulin resistance occurs when there is an amount of insulin being released into the bloodstream in excess than what is required by the equine body. The excess insulin causes an increased amount of glucose intake and causes these horses to be those horses deemed "easy keepers". Many older horses are diagnosed with insulin resistance because they are no longer being exercised consistently and are being over-fed by their owners. This disorder is not typically seen in younger or middle aged horses because they are working animals (Kellon, 2012). The optimal diet to prevent obesity in these horses contains a basic hay species such as alfalfa. For those horses who need additional calories, the diet can include concentrates containing small amounts of simple sugars and a high fat content. Lastly, the diet should contain a balanced ratio of minerals. These minerals should include the minerals previously mentioned in relation to Cushing's based insulin resistance (Frank).

Exercise Physiology

One of the most important aspects of the equine's ability to perform is the musculoskeletal system. The equine muscle consists of two different types of muscle fibers known as Type I and Type II. Type II muscle fiber is further broken down into Type IIA and IIB fibers. Type I fibers are known as the slow twitch type which are slow to contract and relax. They are used in aerobic exercises and mainly to maintain the horse's posture. Type IIB is a fast twitch fiber which is mainly used in the anaerobic exercises such as sprinting for a short period of time. Type IIA is an intermediary fiber. This fiber will be utilized when the muscle is transitioning between aerobic and anaerobic exercise. The horse naturally contains more Type IIB fibers in the muscles of their hindquarters meaning horses are naturally sprinting animals (Marlin, 2002).

As the muscles begin to be conditioned, the amount of capillaries in the muscle increase in response to the increase or decrease of certain muscle fibers. The increase in capillary beds within the muscle decreases the ability for the blood to move through the muscle quickly because the increased number of capillaries creates a larger network for the blood to travel through. However, the blood slows down in the muscle to deposit more oxygen and take up more carbon dioxide and hydrogen ions from the muscle. This will allow the muscle to work for a longer period of time before tiring. The carbon dioxide is taken as a waste product to the lungs to be exhaled out of the body. The increased amount of carbon dioxide in the venous blood changes the gas exchange ratio in the alveoli. The carbon dioxide and oxygen will diffuse more readily across the alveolar membrane due to the large differences between the individual gas concentrations on either side of this membrane. The Type IIB muscle fibers will transition to begin to work like Type IIA muscle fibers, but the physical fibers will not change. Instead, the muscle fiber diameter will decrease allowing these muscles fibers to work aerobically for a

longer period of time. This also allows a larger amount of capillaries to come into contact with the fibers and provide a shorter distance for the oxygen to diffuse through to the mitochondria. The increased amount of oxygen in the mitochondria causes an increase of aerobic enzymes in the mitochondria such as citrate synthase and 3-hydroxyacyl-CoA dehydrogenase. An increased oxygen uptake will also increase the muscle's ability to store more oxygen in the muscle by increasing the amount of myoglobin. This protein is similar to hemoglobin which is the molecule used to transport oxygen in the blood stream, but myoglobin never leaves the muscle. However, a high intensity exercise program will cause anaerobic enzymes to increase such as lactate dehydrogenase, glycogen phosphorylase, and phosphofructokiinase. These enzymes will also lead to a higher lactic acid buffering capacity in the muscle. An increased amount of aerobic exercise will allow the muscles to utilize fat more often while allowing the muscles to store more glycogen in the muscles. This is especially true in horses with mainly Type IIB fibers or fibers utilized for anaerobic exercise. This increases the amount of time the horse can work before the animal is fatigued. Overall, the training needed to make these changes in the muscle will improve the horse's fitness, but will also improve the horse's motor skills. This allows the horse to use less energy when performing maneuvers because the horse knows what is being asked and new neurological pathways are created to coordinate the muscles (Marlin, 2002).

The cardiovascular is another important system in exercise physiology because one of its main functions is to pump blood transferring the oxygen and carbon dioxide to and from the lung and body. Training produces changes to the heart and the vasculature to increase the oxygen carrying capacity and delivery. Under the right circumstances, the first change which can occur is an increase in heart mass by either an increase in wall thickness or an increase in chamber diameter. This change will not occur with minimal exercise such as walking for ten minutes.

This change will occur in horses that have been performing exercises such as cantering continuously for ten minutes. An increase in heart mass from either type of increase will eventually cause the heart rate to decrease while increasing the stroke volume and cardiac output. This means the heart will be able to pump more blood with the same amount of force before conditioning the heart muscle. This allows more blood and oxygen to be delivered to the body with a smaller effort from the heart. Along this same line of thinking, the trained horse will reach their maximal heart rate sooner. Other changes in the cardiovascular system occur in the blood. The plasma volume will increase with even the slightest amount of exercise. This has three benefits. The first benefit is an increased ability to thermoregulate their bodies more efficiently. The blood is normally shunted to the dilated vessels next to the skin to dissipate excess heat. This will be done in spite of the working muscles and will leave the muscles with less blood and oxygen. The increased plasma volume will allow the blood to go to the skin to dissipate heat without taking the blood away from the working muscle. The second benefit is an increase in stroke volume. The amount of blood circulating in the body has increased. Therefore, more blood is entering the right atrium after circulating in the body. The same amount of blood entering the heart must be pumped out of the heart back into circulation. Lastly, the increase in plasma volume will increase the ability of the blood to transport, dilute, redistribute, and eliminate the waste products of metabolism. As plasma volume increases, the amount of red blood cells, specifically hemoglobin, will increase. Therefore, the hemoglobin concentration in the blood remains the same, but the number of cells increases. Hemoglobin is used to carry oxygen and hydrogen ions to their respective places. The increase of this protein allows the animal to have a greater ability to carry oxygen to muscles as well as the ability to give the animal a higher tolerance of hydrogen ions during exercise (Marlin, 2002).

The respiratory system is an organ system which plays a role in exercise physiology. Although the lungs do not undergo any adaptations, oxygen taken up into the body increases thirty percent in the first couple weeks of training due to changes occurring in the muscular and cardiovascular system. The improvements in this system allow the horse to deliver and use the oxygen it takes in more efficiently. Therefore, the horse will be using the aerobic pathways opposed to anaerobic pathways. It is believed the respiratory muscles around the lungs such as the diaphragm will increase about ten percent. However, the increase of these muscles does not change the amount of oxygen breathed in by the animal (Marlin, 2002).

These factors work together to increase the digestibility of the digestive tract. Dry matter digestibility, organic matter digestibility, and neutral detergent fiber were specifically cited to have a significant increase in digestibility. This is believed to be a result of a longer digesta retention time in certain parts of the digestive system while maintaining the overall mean retention time of the entire digestive system. The data suggests exercise causes an increased gastric emptying and increased pre-cecal motility allowing the enzymes to have additional time to breakdown the cellulose and other food components in the cecum (Goachet, 2010).

These processes will occur in a horse who begins exercising at any age. However, older horses beginning this conditioning process may be trying to overcome certain circumstances. The metabolism of these older horses has already begun to slow meaning these processes have to return the system to its previous condition before improving the digestive system. Exercise may also be difficult for certain older horses due to arthritis or obesity. An intense or moderate exercise program could be difficult and/or painful for these horse making them reluctant to work at all (Marlin, 2002).

Conclusions

Geriatric horses see major changes in their metabolisms due to their natural life cycles. However, humans play a major role in the geriatric horse's metabolism and fitness. The geriatric horse who is obese needs plenty of exercise. This exercise will not only help the horse breakdown and use the energy efficiently, but will help to prevent some of the metabolic imbalances such as insulin resistance. For obese horses, weight loss is a major concern. This can be accomplished through exercise and caloric reduction. Despite a caloric reduction, the nutritional value needs to maintain a nutritional balance for a geriatric horse. Skinny horses with a body score of three or less need the ability to gain weight. Although many people would increase the caloric density of the horse's diet, there are other ways to assist the horse in weight gain. Exercise will build the horse's muscle, respiratory system, and cardiovascular system. Although including exercise in a weight gain program will require extra time to increase the body score of the horse, the overall health of the horse will be better than if exercise is not included in the weight gain program. These horses will avoid the risk of obesity and the associated medical risks excess fat creates. Therefore, all of these factors contribute to the weight and nutritional utilization of the horse, but the most important factors are the nutrition and exercise regimen owners employ for each horse.

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