Feeding the Canine Athlete

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June is upon us and another demanding canine sports season is underway. While hot weather tends to lower the activity level and therefore the nutrient requirements of most dogs, working dogs have increased needs as a result of having to perform in hot, humid conditions. This month's column will look at nutritional strategies for enhancing athletic performance in working dogs.

There are five fuels that can be used by the body to drive muscular work: phosphocreatine, glycogen, glucose, fatty acids and amino acids (from protein). The type of work being performed determines which of these fuels are used. The muscles of a sprinter use different fuels than the muscles of a marathon runner.

Extremely short duration, maximum intensity work relies on energy released from phosphocreatine, a molecule present in limited quantities in muscle tissue. The breakdown of phosphocreatine provides maximum power (power = work/time) but lasts for a very short time. For very intense work that lasts no more than 10 seconds, phosphocreatine is the primary source of energy. Examples of dog activities that fall in this category include the French Ring palisade exercise, weight pulling, as well as the high jump and broad jump exercises.

A second potential fuel is glycogen. Glycogen is a carbohydrate which is also stored in muscle tissue. The power produced from the breakdown of glycogen is about half that derived from phosphocreatine, but it lasts a bit longer, up to about 30 seconds.

A third source of energy is glucose. Glucose circulates in the blood and is taken up by muscle cells where it is broken down to yield energy. The ability of muscle to use glucose depends on the availability of glucose in the blood and how quickly it can be moved into muscle cells. Because glucose uptake takes time, the energy derived from glucose yields less power than glycogen however circulating glucose typically outlasts muscle glycogen stores. Glucose becomes the major source of energy for exercise lasting from 30 seconds to a few minutes. Since the liver can replenish glucose in the blood much faster than muscle can replenish its glycogen stores, glucose becomes an important fuel in sports that involve multiple short bursts of activity. Agility is a sport in which competitors (both dogs and handlers!) use glycogen and glucose as the predominant fuels.

The fourth source of fuel is the oxidation of fatty acids. Fatty acids used by muscle cells come from long chain fatty acids circulating in the dog's blood. These fatty acids move into muscle cells by diffusion and their rate of uptake by muscle depends on the fatty acid concentrations in the blood: the higher the fatty acid concentrations in the blood, the faster they are taken up by muscle cells. Once inside muscle cells, fatty acids must be transported into cellular structures called mitochondria where they are converted into fuel. The carrier protein responsible for transporting long chain fatty acids into mitochondria is called carnitine.

Dog sports which last for more than a few minutes use fatty acids for fuel. Within this category there is a wide range of activities, from the sprint of a racing greyhound, to a full day of field work for a hunting dog, to the 1800 plus kilometre trek across arctic tundra that defines the Iditarod sled dog race. With short duration, intense activities, glycogen and glucose still contribute significantly to the fuel used. For longer endurance work, fatty acid oxidation becomes the predominant fuel.

A final source of fuel is amino acids derived from the breakdown of protein. Amino acid oxidation is not a major source of energy for work. It usually represents no more than 5 to 10% of the total energy burned in work regardless of the type of activity performed.

Feeding for stamina

Short duration, high intensity work does not depend on diet to the same degree as prolonged endurance work. While training can enhance the muscular strength and coordination of dogs performing the palisade, diet and training cannot significantly improve a dog's ability to convert phosphocreatine into work. With endurance sports however, diet and training both play a critical role in enhancing the efficiency of energy utilization and maximizing performance.

Human marathon runners generally follow a feeding strategy called "carbohydrate loading" which was first described in 1967 by Bergstrom. Bergstrom demonstrated that diets high in carbohydrate extended the time to muscle glycogen depletion in human marathoners, thereby improving their endurance. While carbohydrate loading is an effective strategy for humans, it is not always a good strategy for dogs.

Dogs participating in activities that use glycogen and glucose as the predominant fuels do benefit from diets high in complex carbohydrates. However, for dogs who work for hours at a time, high carbohydrate diets can be dangerous. Carbohydrate loading in sled dogs results in a condition known as exertional rhabdomyolysis ("tying up"), which causes muscle pain and cramping. High carbohydrate diets fed to endurance dogs often cause watery stools which can quickly lead to dehydration. A better approach for endurance dogs is to increase their daily intake of dietary fat.

High fat intake, in conjunction with endurance training, causes cardiovascular, pulmonary and enzymatic changes which enhance the storage of fat in muscle and increase the dog's ability to use free fatty acids as fuel for muscle activity. These physiological changes, which occur only when a high fat intake is accompanied by an aerobic training program, are referred to as "fat adaptation".

Fat adaptation improves the efficiency of energy utilization in performance animals. One study showed that in fat-adapted race horses, 77% of energy absorbed from their diet was available for athletic activity, while 23% was expended to maintain normal metabolic functions. In non fat-adapted

horses, 34% of absorbed energy was required for metabolic functions, leaving only 64% for athletic activity.

Similar results have been reported in dogs. Racing sled dogs have been shown to perform better on high fat diets than on high carbohydrate diets. Treadmill studies with beagles have shown that feeding high fat diets result in a longer time to exhaustion, while high carbohydrate diets were associated with a more rapid onset of fatigue.

Fat adaptation reduces breathing effort during exercise. During aerobic activity, muscles use oxygen to burn fuels and carbon dioxide is produced as a by-product. Increased heart and respiration rates during exercise facilitate an increased uptake of oxygen and release of carbon dioxide by the lungs. When fatty acids are burned as fuels, less carbon dioxide is produced per unit of oxygen as compared to carbohydrate. Fat adaptation reduces the rise in carbon dioxide levels in venous blood during exercise and this is believed to reduce the breathing effort required during strenuous exercise.

Feeding to maintain hydration

Dehydration is a major concern for all animals competing in hot weather. Dogs lose excessive body heat by panting, so a dog's requirements for water increase with increasing temperature and activity. While mild dehydration may not be life threatening, it can still significantly impair athletic performance. Body water depletion reduces blood volume causing the blood to "thicken". This results in the heart having to work harder to pump blood through the body, preventing the dog from achieving maximum cardiac output. Water depletion is a major cause of fatigue in performance animals.

Food consumption directly affects water requirements. Increased food consumption due to increased activity can double or even triple the amount of water lost in a dog's urine and feces. Urine is required for the elimination of nitrogen from the body, and nitrogen is released when protein is metabolized. Diets which are high in protein therefore promote the production of a greater volume of urine which increases the risks of dehydration. High fibre diets can also contribute to dehydration because they cause an increase in stool volume which increases fecal water losses. High salt diets, while encouraging water consumption, also increase urine output and so can lead to body water depletion.

High fat diets which are moderate in protein help to conserve body fluids in three ways. First, they minimize urine output by reducing the amount of nitrogen which must be eliminated from the body. Second, they provide a more concentrated source of nutrients, thereby minimizing stool volume and fecal water losses. Third, dietary fat contributes "metabolic water". Metabolic water is defined as water produced from the metabolism of nutrients. When 100g of fat, protein and carbohydrates are metabolized, approximately 107g, 40g and 55g of metabolic water are produced respectively. Dietary fat yields more than its weight in metabolic body water.

By far the most important strategy for maintaining hydration in working dogs is to provide clean, fresh water as often as possible. Most people wouldn't dream of going jogging on a hot summer day without taking fluids with them. It's crucial to extend the same courtesy and care to active working dogs.

Supplements can help to improve performance, enhance stamina and hasten recovery after intense exercise. Some examples of nutrients which can be beneficial to canine athletes are listed below.

Supplement	Role
Carnitine (a small protein)	Enhances the ability of muscle to generate energy from long chain fatty acids
Arginine (an amino acid)	May help to prevent hyperammonemia (the build-up of ammonia in the blood) caused by increased protein turnover
Medium chain triglycerides (for example coconut oil)	Shorter fatty acids are absorbed faster into the blood and do not require carnitine for metabolism. They are particularly beneficial for canine endurance athletes.
Omega 6 fatty acids (for example sunflower oil)	Important for the integrity of cell membranes, they help red blood cells carry oxygen
Omega 3 fatty acids (for example fish oil)	Help reduce inflammation, promote healthy recovery after exercise
Calcium and magnesium	Increased dietary fat can increase calcium and magnesium losses in feces. Supplemental calcium and magnesium are important for endurance athletes but not necessary for most dog sports.
B vitamins	Necessary for the production of energy, requirements for a working dog may be triple those of the average dog
Antioxidants (for example vitamin C and E)	Help to repair cells and tissues damaged by exercise, working dogs have an increased requirement for these nutrients
Buffers (for example potassium bicarb)	Help to buffer acidosis caused by lactic acid build-up in muscles, helps reduce muscle ache and muscle fatigue
Glucosamine, chondroitin sulfate	Help to repair damaged cartilage tissue and promote joint health