PEER REVIEWED

Canine Performance & Rehabilitative Nutrition

PART 1: CANINE PERFORMANCE NUTRITION

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Dogs frequently engage in performance-based competitive and recreational activities, ranging from flyball to sled pulling to agility, and nutrition is increasingly used to maximize an animal's potential and stamina. Each canine activity has unique requirements for performance, which influence the caloric requirements and metabolism of individual animals.

Modification of feeding can, therefore, affect a dog's adaptation to such events. An expanding body of evidence suggests best practices for dietary modification in these dogs, and practitioners should be prepared to discuss the growing field of performance nutrition with interested owners.

DOES EVERY CANINE "ATHLETE" NEED MORE CALORIES?

Calories provide the fuel for work. The normal activity of most pet dogs requires:[1]

$$(90–110) \times (\text{ideal body weight in kg})^{0.75} = \text{kcal Q 24 H}$$

Additional activity requires more calorie expenditure. Veterinarians have frequently multiplied the resting energy requirement by a factor to account for the activity level of a dog.[2] However, the increases in energy expenditure by working dogs are directly related to the distance traveled during that work.

Calories Based on Distance

Studies suggest that running dogs require about 1.1 kcal/kg per km traveled.[1]

- Dogs with longer limbs require less energy for trotting than those with short legs (0.6 versus 1.3 kcal/kg per km).[3]
- Dogs traveling short distances, therefore, require fewer calories than similar dogs traveling greater distances. Sprinting greyhounds, for example, require only about 10% more calories on race day compared with nonracing active dogs.[1]
- Huskies pulling sleds in cold weather over extended distances require up to 8× normal energy requirements.[1]

Calories Based on Exercise Duration

Many canine sports require a consistent amount of exercise from participants.

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The primary objectives of the ACVN are to:

- Advance the specialty area of veterinary nutrition
- Increase the competence of those practicing in this field
- Establish requirements for certification in veterinary nutrition
- Encourage continuing education for both specialists and general practitioners
- Promote evidence-based research
- Enhance dissemination of the latest veterinary nutrition knowledge.

The ACVN achieves these objectives in many ways, including designating specialists in animal nutrition, providing continuing education through several media, supporting veterinary nutrition residency programs, and offering a wide array of resources related to veterinary nutrition, such as this column.

CONVERTING CALORIES TO WORK

The Role of Muscles

Muscles allow dogs to perform activity, and muscle fibers are generally classified as type I (slow twitch) or type II (fast twitch).

Type I fibers contain lower amounts of myosin adenosine triphosphatase compared with type II fibers; this difference is responsible for the slower contraction observed in type I fibers.[1]

Type II fibers are subdivided into:

- *Type IIa fibers*, which aerobically metabolize fat or glucose and are much more fatigue resistant than type IIb fibers
- *Type IIb fibers*, which rely more on anaerobic glycolysis and, therefore, experience fatigue faster; however, these fibers permit explosive, but poorly sustained, bursts of activity.

While cats are known to have relatively equal concentrations of type I, IIa, and IIb fibers, dogs possess fiber types that display substantial aerobic and anaerobic capacity, which had led some authors to question whether IIb fibers even exist in this species.[1,5] These species-specific muscle differences are consistent with evolutionary hunting strategies. Dogs are built for endurance hunting; cats for stalking and short chases.[6]

Fuel Sources for Muscles

Duration of muscle activity determines the primary fuel source used for contraction.

- **Adenosine triphosphate** (ATP), in small amounts, is used rapidly at the onset of activity but is quickly depleted.
- **Adenosine diphosphate**, with help from creatine phosphate, can be converted to ATP, but sustains activity only temporarily.
- **Glucose** is subsequently used for aerobic or anaerobic metabolism, and **glycogen** provides reserves for moderate exercise. Short bursts of explosive activity, known as *supramaximal exercise*, can be sustained only as long as glycogen provides glucose for anaerobic metabolism.

Using Fat for Fuel

As the distance and duration of exercise increase, dogs use fat as an aerobic fuel source. Interestingly, dogs at rest also display higher rates of fat oxidation compared with other species. Therefore, fat likely has the most profound effect on increasing stamina in dogs.[1]

Dietary fat is more energy dense than protein and carbohydrate: protein and carbohydrate contain between 3.5 and 4 calories per gram, while fat contains 8.5 to 9 calories per gram. The range arises from the digestibility of the ingredients.

This difference in energy density between fuels means that working dogs can be fed additional calories by increasing fat in the diet rather than the amount of food given. This must be done cautiously to avoid inadvertently creating relative nutrient deficiencies.

TABLE 1. Expected Energy Requirements of Selected Canine Sports

LOW (< 25% increase)	MODERATE	HIGH (> 100% increase)
Agility	Bikejoring (2–10 miles)	Bikejoring (> 10 miles)
Coursing	Carting (2–10 miles)	Carting (> 10 miles)
Disc dog	Field trials	Sled dog racing (> 10 miles)
Dock jumping	Herding	
Earthdog	Hunting	
Flyball	Weight pulling	
Greyhound racing		

- Short bursts of explosive activity—common in sports, such as flyball or agility—require only small increases in calories.
- Conversely, endurance sports, such as field trials, hunting, and cart pulling, require more energy given the greater distance dogs must traverse.

Such information can be used to classify canine sports according to expected energy requirements (**Table 1**).[4]

In addition to distance and exercise duration, other factors, such as thermal stress, terrain or slope, and ambient temperature, should be considered.

DIETS FOR PERFORMANCE DOGS

The guaranteed analysis found on dog food packaging is the primary reference for owners, but is of little utility for comparing pet foods. Instead, nutrients are best expressed on a caloric basis, commonly related as the mass (g) of a given nutrient per 1000 Calories (kcal).

This value can be estimated from the guaranteed analysis by using a calculation method described in **Beyond the Guaranteed Analysis: Comparing Pet Foods**, available at tvpjournal.com in the Resources section (see In-Clinic Materials).

Dietary modification for active dogs should be based on the distance of activity, irrespective of the perceived intensity (**Figure**), and dietary recommendations can be based on the type of activities in which a dog participates.

Short Distance Athletes

- Most research published is based on racing greyhounds.[1] The normal body condition score for such sighthounds is 3 to 4 using a 9-point scale as opposed to 4 to 5 in other breeds.

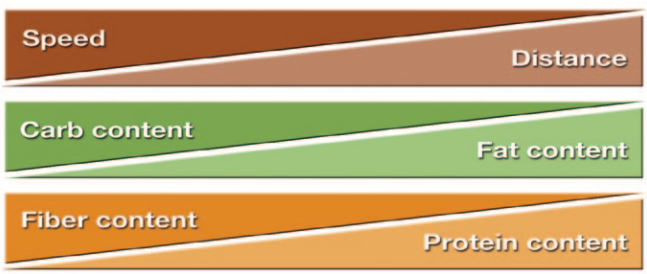

Figure. *Nutritional trade-offs in diet selection.*

- Anaerobic energy is used exclusively for the first several seconds, but 50% of the energy required is obtained aerobically in the first minute of a race.[1,7]
- Carbohydrate is used as a primary fuel, and modest increases in dietary carbohydrate may confer a small benefit. The recommended carbohydrate amount is 105 to 135 g/1000 kcal.[8,9] Commercial diets range from minimal amounts (< 5 g/1000 kcal) in some canned diets to 150 g/1000 kcal in low-protein, low-fat, high-carbohydrate dry diets, with an average of around 100 g/1000 kcal in dry foods. Carbohydrates used in pet foods are often complex, and simple sugars are only infrequently used in performance dogs for post-exercise glycogen repletion when several runs or trials of intense activity are expected.
- Fat oxidation also occurs; therefore, dietary fat should be moderate (> 30 g/1000 kcal).
- Pre-race fasting (> 8 hours) or caloric restriction may improve performance due to reduced fecal mass.[1]
- Most commercial diets for adult maintenance, whether dry, canned, or frozen, fulfill the nutritional recommendations for short distance athletes: a typical target dietary concentration for macronutrients per 1000 kcal is **60 g protein**, **40 g fat**, and **100 g carbohydrate**.[4]

Long Distance & Endurance Athletes

- Sled dogs were primary subjects of endurance exercise research.
- While increased carbohydrate does not improve stamina, increased dietary fat improves long-distance performance.[1]
- Beagles fed a high fat diet (> 50 g/1000 kcal) were *not* exhausted until after 20 miles; when fed a lower fat diet (33 g/1000 kcal), they were exhausted at 15 miles.[10]
- Dietary protein requirements increase with long-distance exercise,[1] and select amino acids support gluconeogenesis.
- Diets containing a minimum of **90 g protein**, **60 g fat**, and **25 g carbohydrate** per 1000 kcal are recommended based on current research.[1] Most diets in this category are also low in insoluble fiber (or crude fiber), which allows the diet to have a greater energy density to meet the increased calorie requirements for long-distance activity. Soluble fibers, such as gums and oligosaccharides, may still be beneficial in small amounts to provide a substrate for normal intestinal bacteria.

Dogs engaging in multiday activities may benefit from post-exercise carbohydrate administration to facilitate glycogen repletion.[11]

WATER & ELECTROLYTE REQUIREMENTS DURING EXERCISE

Owners of working dogs understand that hydration is critical to safe and maximal performance. Veterinarians working with athletic dogs may encounter inquiries about the best ways to rehydrate animals after exercise.

Water Requirements

- Sedentary dogs require 0.6 to 1 mL of water per calorie Q 24 H.[1] This approximates 50 to 100 mL/kg/day, with smaller dogs requiring more water per kg of body weight.
- Dogs continue to consume water even if dietary moisture is very high, and water intake rises with increases in plasma sodium and urea.
- Temperature, duration of exercise, and efficiency of

DIETARY SUPPLEMENTS

Performance Enhancers or Clever Marketing?

Dietary supplements are reviewed extensively in **Surveying Supplements: Current Trends, Research, & Recommendations** (May/June 2014), available at tvpjournal.com. Owners of performance dogs more frequently administer several specific supplements; the usefulness of these supplements is outlined in **Table 2**.

TABLE 2. Common Dietary Supplements for Performance Dogs

SUPPLEMENT	NEEDED FOR PERFORMANCE?	COMMENTS
Creatine	No	• Marketed as a way to increase ATP stores • No evidence that it is effective or increases performance
Minerals	No	• Do *not* need to be added to commercial pet foods for active dogs • Active dogs eat more and, given the fixed ratio of minerals to calories, such dogs also consume more minerals
Vitamin C	No*	• In dogs, vitamin C is synthesized from glucose • Greyhounds ran more slowly when receiving vitamin C (1 g Q 24 H)[13] • Supplementation with this antioxidant is *not* recommended
Vitamin E	No*	• Primary antioxidant within the cell membrane • Diets high in polyunsaturated fats require additive vitamin E to combat free radical formation • However, racing greyhounds ran slower when 1000 IU of supplemental vitamin E was administered Q 24 H[14] • Properly formulated commercial diets do *not* require vitamin E supplementation

* Some vitamin requirements are affected by the macronutrient composition of the diet; however, increased food intake and liberal safety factors in commercial diets minimize the need for additional intake.

panting (dependent on airway structure and humidity) are the primary determinants of water needs.
- After exercise, dogs anticipate the need for more water but drink more only if offered water immediately after exercise; those offered water just 5 minutes after exercise drank only if they were > 0.5% to 1% dehydrated.[12]

Electrolyte Requirements

Human athletes are familiar with electrolyte considerations during performance; however, dogs have important differences in electrolyte handling:
- Exercising dogs develop natriuresis, which prevents an increase in plasma osmolality despite dehydration.[1] Post-exercise potassium changes are rarely significant enough to warrant supplementation beyond the amount found in commercial diets.
- Free water consumption after exercise rapidly corrects dehydration, and the kidneys adjust sodium balance.
- Maintenance pet foods provide adequate electrolytes for exercise; additive dietary sodium is required during initial training *only* if an animal is fed a low-sodium diet.
- Additional supplementation with electrolytes, fluids, or sports drinks has never been associated with any scientifically proven benefit.

FEEDING PERFORMANCE DOGS BASED ON AGE

Feeding Potential Athletes During Growth

Owners may acquire and train young growing dogs with the intent of competing in canine sports. Nutritional requirements are generally much narrower during growth; therefore, consideration of appropriate feeding is critical.

1. **Precisely control calcium and vitamin D concentrations.**
- Excess calcium in large breed dogs, such as Great Danes, alters endochondral ossification, skeletal maturation, and osteoclastic activity. Puppies are more likely to absorb calcium linearly as the dietary content increases.[15]
- Low calcium or vitamin D may cause nutritional secondary hyperparathyroidism and pathologic fractures due to reduced bone density.[16]
- An allowance of 3 g of calcium/1000 kcal, and a minimum of 2 g/1000 kcal, has been recommended for puppies.[1] An average commercial dog food containing 3500 kcal/kg of diet would likely have a guaranteed analysis of 0.7 to 1.1% calcium. However, this guaranteed value on the label represents a minimum amount in the diet and should be interpreted with caution.
- A safe upper limit of 4.5 g of calcium/1000 kcal has been suggested for giant breed puppies.[1] Large breed formulas generally conform to these guidelines, but feeding adult foods may produce deficiencies in essential nutrients.

2. **Avoid excess caloric intake.**
- A relationship between overfeeding and osteochondritis dissecans, hip dysplasia, and other skeletal abnormalities has been established.[17,18]
- Puppies should maintain a normal body condition, objectively assessed by using body scoring charts.
- The total energy intake of a dog at 4 months of age is often similar to the energy intake of a young adult (1–2 years old); this can be used as a guide to provide feeding recommendations. Caloric intake recommendations found on product labels are inconsistent and unreliable in many cases.

3. **Critically evaluate home prepared, raw diets, and other alternative feeding strategies** during growth, when the effects of dietary deficiency or excess are most profound.

TABLE 3. Suggested Target Macronutrient Profiles for Performance Dogs

PATIENT	PROTEIN	FAT	CARBOHYDRATE	EPA + DHA
Short-distance adult athlete	60	40	100	> 0.5
Long-distance (endurance) adult athlete	90	60	25	> 0.5
Growing potential athlete	> 70	> 35	< 100	> 0.5
Active senior dog	> 75	> 35	< 100	0.5–3

Nutrient values given in g/1000 kcal

Special Foods for Senior Athletes?

Senior dogs have decreased performance and reduced maximal energy expenditure, which is probably related to a loss in lean body mass (muscle), secondary to sarcopenia, inactivity, or increased muscle turnover.[19]

Senior diets should be critically evaluated by the following considerations to determine whether they are appropriate:
- Some senior diets may have reduced protein and phosphorus based on an unproven theory that such reductions decrease the risk of renal disease, while other senior diets may be reduced in fat to prevent weight gain and obesity.
- Active senior pets in normal body condition benefit from diets with elevated protein and fat to preserve muscle mass and calorie intake, respectively.
- Diets containing greater than 75 g of protein and 35 g of fat/1000 kcal are recommended for healthy, active senior dogs.[20] Guaranteed analysis values for these diets are often greater than 26% minimum protein and 13% minimum fat in dry foods.

Both retired and competing geriatric athletes may benefit from rehabilitation and the related nutritional interventions, which will be discussed in Part 2 of this article series.

PERFORMANCE NUTRITION: IN SUMMARY

Nutrition is a cornerstone of any veterinary assessment, and the evaluation of performance should include dietary analysis. The aforementioned distance-dependent energy requirements and nutrient considerations provide simple principles for optimizing an animal's potential, as outlined in **Table 3**.

ATP = adenosine triphosphate; DHA = docosahexaenoic acid; EPA = eicosapentaenoic acid

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