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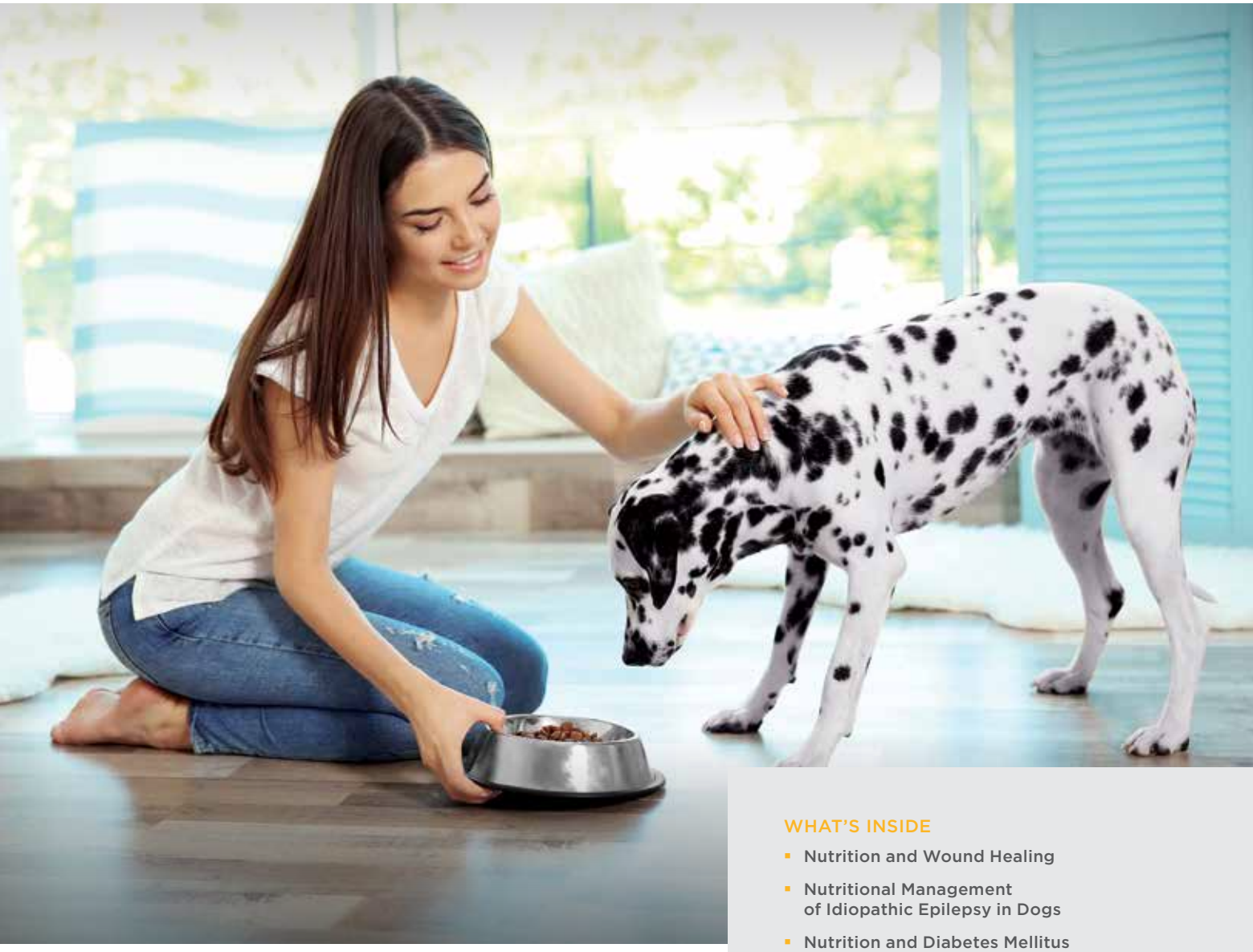
Issues in Nutrition



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TODAY'S VETERINARY PRACTICE

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Nutrition and Wound Healing

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Assurance of adequate patient nutrition is, perhaps, one of the most underappreciated facets of wound healing. Healing requires the body to have sufficient energy stores, in the form of fats and carbohydrates, to rebuild tissue. Without these resources, the body begins to break down endogenous protein in an attempt to meet its needs for the "building blocks" of healing. Nutritional support is therefore critical for animals with healing wounds, and a strategy to provide adequate nutrients should be created for every wound patient.

Protein also helps with the prevention of edema. Glucose provides energy to leukocytes and fibroblasts, which are critical components in collagen formation and wound strength.

KEY NUTRIENTS FOR WOUND HEALING

Animals with wounds are in a catabolic state, and without appropriate nutritional intake, they are often in a negative nitrogen balance. This state can contribute to slower wound healing times or even failure to heal.

Protein and glucose are key nutrients for healing. A plasma protein level of less than or equal to 6.0 g/dL (normal, 7.0 to 7.5 g/dL) is associated with slower healing, and levels less than 5.5 g/dL increase the risk of failure to heal by 70%.[1,3] Protein also helps with the prevention of edema. Glucose provides energy to leukocytes and fibroblasts, which are critical components in collagen formation and wound strength. Therefore, inadequate dietary intake of these 2 nutrients not only delays healing but also contributes to ineffective development of the wound bed and wound strength.

CALCULATING NUTRITIONAL NEEDS

The goals of nutritional support are to maintain the patient's body weight and avoid overfeeding.

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BOX 1 Factors in Choosing Feeding Tubes

- Patient status and ability to tolerate sedation and anesthesia
- Available tubes and diets
- Staff technical skill in tube placement
- Expected duration of tube feeding
- Owner comfort and motivation in performing tube feeding

Calculating energy requirements is a good place to begin. Quite simply, a patient should be fed enough to meet daily metabolic needs. For a hospitalized patient, this amount is estimated as the resting energy requirement (RER), calculated as:

$$RER = 70(\text{body weight in kilograms})^{0.75}$$

For wound patients with a normal protein tolerance, protein intake should start at 4 to 6 g of protein per 100 kcal (15% to 25% of total energy) for dogs and 6 g of protein per 100 kcal (25% to 35% of total energy) for cats. In animals with overwhelming wounds (e.g., burn wounds, degloving injuries), this amount may need to be adjusted to meet increased protein needs.[1]

After tube placement, feedings of previously anorexic patients should begin with 25% to 50% of the patient's RER and increased to full RER over the following 2 to 4 days.

"Illness factors" based on the degree of critical illness/injury are no longer used to estimate greater nutritional needs. Therefore, rather than guess at individual patient needs by using general formulas for patients with differing degrees of wound compromise, it is best to begin with the RER and then assess the patient's response and adjust the calories delivered accordingly.

If the patient eats voluntarily, it is possible to calculate a "food dosage." Regular reassessment (based on objective and subjective parameters such as those for assisted feeding, below) is necessary to ensure that nutritional needs continue to be met.

OPTIONS FOR ASSISTED FEEDING

When voluntary intake falls short of meeting nutritional needs, enteral feeding is preferred, as feeding through the gastrointestinal (GI) tract helps maintain intestinal health. A feeding tube should be considered, especially if the patient is being sedated or anesthetized for wound treatment. Nasoesophageal and nasogastric tubes can often be placed easily with local anesthetic or light sedation. Esophagostomy tubes require general anesthesia but may be tolerated better.

Feeding patients as far proximal as possible in the GI tract is recommended, as is being proactive about feeding tube placement, especially if the animal shows any reluctance to eat in the first 2 to 3 days after injury or wound treatment.

Monitoring parameters in these patients should include physical examination findings, body weight (obtained at least every 12 hours), GI signs, blood work (packed cell volume/total protein, glucose, electrolytes), tube placement/stoma site assessment, and hydration status.

FEEDING TUBES

Options for feeding tubes in wound patients include nasoesophageal, nasogastric, esophagostomy, gastrotomy, and jejunostomy tubes. All types are well tolerated by patients. The decision of which to place is based on the factors in **BOX 1**.

After tube placement, feedings of previously anorexic patients should begin with 25% to 50% of the patient's RER and increased to full RER over the following 2 to 4 days. If the animal was eating up until the time of trauma or hospitalization, more aggressive feedings are often possible.

Nasoesophageal and Nasogastric

Nasoesophageal and nasogastric feeding tubes are easy to place using a local anesthetic in the nares (ophthalmic proparacaine hydrochloride) or light systemic sedation. Patients with upper respiratory issues, facial trauma, or coagulopathy and patients that

are unable to protect their airway are not candidates for this feeding method.

A small-bore (3.5- to 8-Fr) silicone, polyurethane, or red rubber tube is most commonly used and is placed through the nares into the distal third of the esophagus (nasoesophageal) or stomach (nasogastric). It is critical to measure and mark the tube before insertion and document its final location radiographically at the time of placement. An Elizabethan collar should be placed to discourage inadvertent patient removal. Patients may dislodge the tube by vomiting or sneezing.

This feeding tube option is best suited for short-term use (maximum of 7 to 10 days) and, because of the small tube diameter, a liquid diet is the only reasonable diet that can be used.

Esophagostomy

Esophagostomy tubes require general anesthesia and greater technical skill for placement but are well tolerated by patients. Their placement is well described in the literature,[3] and assistance should be sought from someone confident in the procedure.

These tubes are larger (12 to 22 Fr) and include silicone, polyurethane, or red rubber tubes. They most frequently enter at the level of the left proximal to midcervical area and terminate in the distal esophagus. Radiographs (orthogonal views) should be taken to document final tube placement. Although a stoma is created, if the tube is removed immediately after placement, the area can be expected to heal without incident. Local cellulitis or infection at the entrance site is possible, so covering the tube with a light wrap is recommended. If the patient is prone to scratching at the tube entry site, an Elizabethan collar should be used.

A more substantial diet (such as liquefied canned food) can be used with these tubes and is a good option if longer use is anticipated. Animals will eat while the tube is in place, so placing it before needing to use it is not typically problematic.

Gastrostomy

A gastrostomy tube is a good long-term option in animals that are not candidates for the feeding tubes described above. Gastrostomy tubes are typically larger, mushroom-tipped tubes that can be placed percutaneously or through endoscopic or surgical procedures, which can be more technically challenging. Although well tolerated, gastrostomy tubes must be left in place for at least 2 weeks before removal. These tubes can leak and cause irritation or peritonitis.

Jejunostomy

Jejunostomy tubes are not typically necessary for nutrition in wound patients; however, when feeding distal to the duodenum is necessary, they are an option. The tubes used are usually smaller (<8 Fr) and are technically challenging to place appropriately.

Because of the small tube diameter, constant rate infusion of a liquid diet is often required to meet nutritional needs. The disadvantages of these tubes include peritonitis, irritation, or infection at the stoma site and clogging of the tube.

PARENTERAL NUTRITION

When oral or enteral feeding is not an option, parenteral (intravenous) nutrition can be considered. Feeding using the GI tract is usually not a problem in wound patients, but severely compromised patients may benefit from parenteral nutrition. TVP

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Nutritional Management of Idiopathic Epilepsy in Dogs

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Epilepsy is the most common chronic neurologic disorder encountered in small animal practice[1] and is estimated to affect up to 0.75% of dogs in the general population.[2,3] Idiopathic epilepsy, a clinical syndrome characterized by recurrent seizures for which there is no underlying cause other than a presumed genetic predisposition, is diagnosed in most affected dogs.[4,5] Antiepileptic drugs (AEDs) are the cornerstone of therapy for idiopathic epilepsy, and treatment is often lifelong.

Up to 30% of dogs with idiopathic epilepsy are classified as *drug resistant*;[6] that is, they fail to achieve satisfactory seizure control after adequate trials of 2 or more tolerated and appropriately chosen and administered AEDs. Drug resistance poses a serious challenge in the management of epilepsy, as poor seizure control is associated with increased morbidity and fatality[7,8] and can place a considerable financial and emotional burden on caregivers.[7,9] Furthermore, medication-related adverse effects are common in dogs with epilepsy (more than 80% of dogs), and these effects are associated with a worsening of quality of life.[9]

More recently, evidence has emerged to suggest that dietary therapy may have a beneficial effect on seizure control as well.[12,13]

CLINICAL ASPECTS OF NUTRITION AND EPILEPSY MANAGEMENT

The importance of nutrition in optimizing AED therapy is established.[10,11] More recently, evidence has emerged to suggest that dietary therapy may have a beneficial effect on seizure control as well.[12,13] Efforts to develop treatment protocols that include the use of nutritional approaches to improve seizure control while minimizing adverse effects of treatment are ongoing.

In a recent survey of owners of dogs with idiopathic epilepsy, two-thirds reported changing their dog's diet since the diagnosis of epilepsy, and nearly half administered a dietary supplement to help manage their

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dog's epilepsy, with the goal of either reducing the frequency or severity of seizures or offering protection from potential AED-related adverse effects.[14] However, less than 20% of owners consulted their veterinarian on the use of supplements; rather, most advice was obtained from online sources.[14] Hence, it is important for veterinary practitioners to understand the scientific basis for proposed nutritional strategies in the management of canine epilepsy to be able to best assist and educate their clients.

ROLE OF NUTRITION IN OPTIMIZING AED THERAPY

Dietary factors can influence the disposition of AEDs in the body, thereby affecting efficacy. For example, bromide is excreted in the urine, competing with chloride for renal tubular reabsorption, such that alterations in chloride intake can affect serum bromide concentrations.[10] A high-chloride diet leads to an increase in bromide excretion and lower serum concentration, while a low-chloride diet has the opposite effect. To avoid fluctuations in serum bromide concentrations, dogs' daily diet, including treats, should be kept consistent. Phenobarbital metabolism can also be affected by diet; a pharmacokinetic study in healthy dogs demonstrated that dietary restriction of protein or fat can significantly increase this drug's clearance.[11]

Owners should be advised of these interactions, and any necessary dietary change should be performed gradually and under the supervision of a veterinarian, with serum AED concentrations monitored during the transition.

DIETARY THERAPY AS AN ADJUNCTIVE TREATMENT FOR EPILEPSY

Further details of the studies discussed below are summarized in **TABLE 1**. All but one of the studies were randomized controlled trials, which provide the highest quality of evidence when assessing a novel treatment. However, because all of the available data come from a small number of studies involving relatively low numbers of dogs, the strength of any conclusions that can be made regarding the efficacy of these therapies is limited.

Ketogenic Diet

In humans, the ketogenic diet is an efficacious,

TABLE 1 Summary of Published Clinical Studies Evaluating Nutritional Interventions as a Treatment for Drug-Resistant Epilepsy in Dogs

DIET STUDIED	STUDY DESIGN	STUDY DURATION	NUMBER OF DOGS	INTERVENTIONS	MONTHLY SEIZURE FREQUENCY	*P* VALUE
Ketogenic diet[15]	Randomized, double-blind, placebo-controlled, parallel	**BASELINE:** 3–6 months **STUDY PERIOD:** 3 months	12 (6/group)	■ Ketogenic diet (57% fat, 5.8% NFE, 28% protein) ■ Control diet (16% fat, 54% NFE, 25% protein)	2.35 1.36	.17
MCT oil diet[12]	Randomized, double-blind, placebo-controlled, crossover	**BASELINE:** none **STUDY DURATION:** 6 months (2 3-month periods)	21	■ Purina® ProPlan® Veterinary Diets Neurocare™ ■ Control diet	2.31 2.67	.020
MCT oil supplement[13]	Randomized, double-blind, placebo-controlled, crossover	**BASELINE:** none **STUDY DURATION:** 6 months (2 3-month periods)	NR	■ 9% MCT oil ■ Placebo oil	2.51 2.67	.015
Omega-3 fatty acids[16]	Randomized, single-blind, placebo-controlled, crossover	**BASELINE:** none **STUDY DURATION:** 24 weeks (2 12-week periods)	15	■ 400 mg EPA, 250 mg DHA, 22 mg vitamin E/1.5 mL; dosed at 1.5 mg/10 kg q24h ■ Olive oil	0.97 1.46	.1

DHA=docosahexaenoic acid; EPA=eicosapentaenoic acid; NFE=nitrogen free extract; NR=not reported.

alternative therapy for drug-resistant epilepsy. This high-fat, low-carbohydrate diet is designed to mimic the biochemical changes of fasting, which has long been recognized to influence seizure control. Its proposed anticonvulsant mechanisms include altered neuronal excitability via enhanced mitochondrial energy metabolism, changes in synaptic function, and inhibition of glutaminergic neurotransmission.[17] One study has evaluated a high-fat, low-carbohydrate diet as a treatment for dogs with drug-resistant epilepsy. No statistically significant difference in seizure frequency between the treatment and control groups was identified, but dogs fed the ketogenic diet did not achieve a level of ketosis associated with seizure control in humans.[15]

Modifications to the ketogenic diet have been introduced for humans, primarily to improve palatability and compliance. The medium-chain triglyceride (MCT) diet substitutes medium-chain fatty acids for a portion of the long-chain fatty acids in the classic ketogenic diet. This modification is based on the premise that MCTs are efficiently absorbed from the gastrointestinal tract and are more ketogenic than long-chain triglycerides, thereby allowing more carbohydrate in the diet without compromising the ketogenic basis.[18]

A study designed to evaluate a diet enhanced with MCTs as a treatment for drug-resistant idiopathic epilepsy in dogs identified a significant reduction in seizure frequency and seizure day frequency in dogs fed the test diet compared with the control diet.[12] These results were corroborated in a subsequent study comparing a 9% MCT dietary supplement to placebo oil as an adjunctive treatment in epileptic dogs with poorly controlled seizures, in which seizure frequency and seizure day frequency were significantly lower in dogs receiving the MCT supplement compared with control.[13]

Omega-3 Fatty Acid Supplementation

Omega-3 fatty acid supplementation has also been proposed as a treatment for epilepsy, as both eicosapentanoic acid (EPA) and docosahexaenoic acid (DHA) can reduce neuronal excitability by modulating ionic channels and have been shown to have an anticonvulsant effect in rodent models.[19] A study evaluating omega-3 fatty acid supplementation as a treatment for dogs with drug-resistant idiopathic epilepsy failed to identify a difference in seizure frequency or severity compared with placebo.[16]

The medium-chain triglyceride diet substitutes medium-chain fatty acids for a portion of the long-chain fatty acids in the classic ketogenic diet.

Hypoallergenic Diet

The use of hypoallergenic diets as a treatment for epilepsy in dogs was described in a retrospective study that has only been published in abstract form.[20] Seven of 8 dogs were reported to experience a reduction in the frequency and severity of seizures with the introduction of an exclusion diet.

CONCLUSIONS

The role of nutrition in the management of epilepsy in dogs continues to evolve. It is recommended that any dietary alterations be made gradually and under the supervision of a veterinarian to avoid potential changes in AED disposition. Nutritional therapy as an adjunct to AEDs in the management of drug-resistant epilepsy holds promise, particularly the use of MCTs; however, there is currently insufficient evidence to support a strong recommendation for its use. Additional trials involving larger study populations are warranted to further discern the role of diet and nutritional supplements in the treatment of epilepsy in dogs. TVP

Karen Muñana

Dr. Muñana earned her BS from the University of California at Berkeley and her DVM from the University of California at Davis. She completed a small animal rotating internship at Kansas State University and a neurology/neurosurgery residency training program at Colorado State University. She then joined the faculty at North Carolina State University College of Veterinary Medicine, where she is currently a professor of neurology. Dr. Muñana's research interest is canine epilepsy, with a focus on the use of clinical trials to evaluate the effectiveness of novel antiseizure therapies and better understand factors that influence treatment response.

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Nutrition and Diabetes Mellitus

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Diabetes mellitus (DM) is a metabolic disorder that results from impaired glucose handling (lack of insulin production or lack of response to insulin) such that the animal experiences persistent hyperglycemia and glucosuria. As it is for many diseases, an essential part of therapy for DM is nutrition. This article reviews the role of nutrition in the management of dogs and cats with DM.

DOES DM AFFECT DOGS AND CATS DIFFERENTLY?

In veterinary medicine, DM is divided into 2 types, which affect dogs and cats at different frequencies. The 2 types are based on pathophysiology and risk factors, which have been more fully described in human medicine.

- **Type 1 DM** occurs primarily in dogs. It results from destruction of the insulin-secreting beta cells in the endocrine portion of the pancreas, as a result of either immune-mediated (presumably autoimmune) mechanisms or pancreatitis.
- **Type 2 DM** is more prevalent in cats and results from insulin resistance. Receptors on target cells become less responsive to insulin, requiring increased insulin synthesis and secretion to maintain euglycemia. Initially, the beta cells can compensate by secreting more and more insulin; however, over time and consistent exposure to a hyperglycemic environment, the beta cells begin to fail (beta cell burnout). This process is accompanied by amyloid deposition in the failing pancreas, and type 2 DM ensues.

In cats, a unique feature of DM is the possibility of remission (previously referred to as transient DM). Cats experiencing remission might resume a euglycemic state, such that treatment can be discontinued for some time; however, for most of these cats, the diabetic state returns. In the veterinary literature, the definition of remission is not consistent, which has caused confusion over which treatment options result in remission.

WHAT ARE THE RISK FACTORS FOR DM?

Among humans, type 2 DM has reached epidemic proportions, and the prevalence is rapidly increasing. It is estimated that by the year 2025, as many as 300 million people worldwide will have type 2 DM. Significant risk factors for type 2 DM in people center on unhealthy lifestyles, including inactivity and obesity. Similarly, for cats, inactivity and obesity are significant risk factors for DM and type 2 DM is also on the rise. As companion animals, cats' lifestyles often reflect

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those of the people they live with, enabling the cats to enjoy a sedentary life with access to excess calories. Many cats are kept indoors and lack access to activity. In addition, because cats often prefer to graze—eating small amounts of food throughout the day—many people keep dry food available for their cats to consume ad libitum. This combination of a sedentary lifestyle and constant access to calorie-dense dry food contributes to obesity in cats, which can then result in the development of type 2 DM.

WHAT DIET REGIMEN SHOULD I RECOMMEND FOR MY DIABETIC PATIENTS?

After a diagnosis of DM has been made, affected dogs and cats should be fed twice a day, when they receive their insulin injection. This regimen helps ensure that the animal eats enough to use the exogenous insulin. At 4 to 8 hours after injection, when the insulin is working, the animal may have a snack; however, clients should control the animal's calorie consumption to avoid weight gain. The daily caloric requirement, especially for overweight animals, should be divided into the requisite meals and snacks. For cats, rather than trying to change their preference for grazing (an exercise in futility), work with the client to develop an optimal feeding strategy. Most diabetic cats can do well with insulin injections and food left out for grazing. If possible, the cat's caloric requirements should be divided into 2 meals per day and the cat should be allowed to nibble on the food throughout the day.

WHAT FOOD SHOULD I RECOMMEND FOR MY DIABETIC PATIENTS?

For dogs with DM, the optimal diet is high in insoluble fiber. This diet controls glucose absorption from the gut and minimizes postprandial hyperglycemic peaks. For optimal DM control, clients are instructed to feed and give the dog insulin twice daily. As the insulin begins to be absorbed after injection, it should allow the glucose absorbed from the food to be used or stored appropriately. A high-fiber diet also helps the dog lose weight, which can have a beneficial impact on DM control. Food choices for diabetic dogs are much less important than those for cats. For dogs, it is more important that they eat regularly than be strictly limited to certain foods.

For cats with DM, diet is much more important and can significantly affect DM control. For these obligate carnivores, the optimal diet contains 12% metabolizable energy (ME) of carbohydrates. In addition, to prevent loss of lean body mass, a high-protein diet with at least 40% ME protein is recommended. There are many prescription diets on the market that have a low carbohydrate load and are formulated especially for cats. If clients will not purchase prescription low-carbohydrate diets, they can feed nonprescription canned foods; besides being generally less calorie dense, canned cat food also tends to be lower in carbohydrates. For diabetic cats in whom DM is stable and serum blood glucose is less than 300 mg/dL, a low-carbohydrate diet may be tried initially before insulin therapy to determine if remission can be achieved. However, if diet alone does not lead to euglycemia in 2 to 4 weeks, insulin therapy should be started. Insulin therapy should also be initiated if the cat is ketotic, even if eating and drinking normally.

WHAT IF THE DIABETIC PATIENT WILL NOT EAT?

Anorexia can lead to ketosis, which is an emergency situation. Ketosis is a metabolic condition resulting from an increased concentration of ketone bodies, which cause hyperosmolality and acidosis and can lead to a rapid decline in clinical condition. Ketosis occurs when the body's balance of insulin and glucagon is altered, either from decreased insulin or increased glucagon in the bloodstream. Because one cannot remove glucagon from the system, supplementing with insulin is the best way to reverse the abnormal insulin:glucagon ratio and treat ketosis. The rule of thumb is that ketosis indicates that the patient needs more insulin. Conversely, abrupt withdrawal of insulin can alter the insulin:glucagon ratio and result in development of ketone bodies. Therefore, if a diabetic animal will not eat, it should be given half its normal insulin dose to prevent ketosis. Doing so will usually *not* result in hypoglycemia. If the animal continues to not eat well, it should be taken to the veterinarian to check for ketosis, hypoglycemia, or concurrent disease.

WHAT IS THE OPTIMAL FOOD FOR THE DIABETIC ANIMAL WITH A COMORBID CONDITION?

Some DM patients have a concurrent disease and would benefit from feeding recommendations other than those for DM alone. For these patients, the food choice should be based on which disease would benefit the most from nutritional intervention.

For instance, what is the appropriate food choice for a dog with inflammatory bowel disease (IBD) and DM? For a dog with IBD, a limited-antigen or hydrolyzed diet can significantly decrease gut inflammation and may reduce or eliminate the need for medical therapy; however, for a dog with DM, a diet high in insoluble fiber is ideal for slow glucose absorption. For a dog with both of these diseases, the need to control the IBD outweighs the need to control the DM, so the dog should be fed to manage the IBD.

Another example is a cat with DM and stage 2 chronic kidney disease (CKD). Dietary therapy plays an important role in preventing progression of CKD. Therefore, although a low-carbohydrate/high-protein diet can significantly affect glucose control in diabetic cats, it is more beneficial to feed to prevent CKD progression. Therefore, a cat with these comorbidities should be fed a renal diet, and the insulin dose should be increased to compensate for lack of glucose control. TVP

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Nutrition and Osteoarthritis: What Do We Know?

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Osteoarthritis is a common problem among dogs and increases with age. Nutrition can be one tool for preventing and managing osteoarthritis in dogs. This article discusses the role of 4 nutritional approaches that are used to prevent or treat this disease. The value of some approaches remains uncertain, and research is ongoing. This article summarizes current research findings and provides references for more in-depth review.

DIET

The role of nutrition in development of musculoskeletal disease in growing dogs has been recognized for decades. Developmental orthopedic disease (DOD) refers to a group of skeletal abnormalities that affect primarily fast-growing, large, and giant breed dogs. Risk factors among dogs already at genetic risk are nutrient excess (calcium and energy) and rapid growth (overfeeding and excess energy in diet).[1-5] Increased risk for DOD has been associated with dietary calcium >3% on a dry matter basis, despite an appropriate calcium-to-phosphorous ratio.[2] Another cause of excess calcium intake is client-provided treats and/or calcium-containing supplements. For example, 2 level teaspoons of calcium carbonate (10 to 15 antacid tablets) added to a large breed puppy's daily intake doubles the calcium intake. Diets formulated for growth of large and giant breed dogs contain less energy and calcium and higher protein than growth diets for smaller dogs. Commercial diets for puppies at risk for DOD display the following statement from the Association of American Feed Control Officials (AAFCO): "[Pet food name] is formulated to meet the nutritional levels established by the AAFCO Dog Food Nutrient Profiles for growth/all life stages *including* growth of large-size dogs (70 lbs or more as an adult)." In addition, prevention of DOD in dogs has been associated with restricted food intake during growth, which slows the rate of growth without reducing adult body size.[6,7]

WEIGHT CONTROL

Obesity is the condition of having accumulated body fat that negatively affects health, including increased risk for osteoarthritis. Obesity can result in osteoarthritis because of the excess forces placed on joints and articular cartilage, which may lead to inactivity and further weight gain. Thus, a vicious cycle ensues. But perhaps more clinically relevant, adipose tissue is metabolically active and pro-inflammatory; therefore, obesity may contribute to inflammation.[8-12] The negative effects of excess weight may be obvious in an obese dog, especially when obesity-related disease is

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present, but should not be overlooked in an overweight but otherwise clinically healthy dog.

Body Condition Score

Assigning a body condition score (BCS) and muscle condition score is essential for preventing the conditions of being overweight (BCS 6-7/9) or obese (BCS 8-9/9). Quantitatively, obesity is defined as exceeding ideal body weight by 30% or more.

Risk for Osteoarthritis

Several studies have demonstrated a relationship between overweight and obese dogs and osteoarthritis;[9] however, a cause and effect has not been found.[13,14] A long-term study of 48 dogs fed the same diet found that those fed 25% less quantity experienced longer delay to development of chronic disease, including osteoarthritis.[15] They also weighed less, had better BCS, and lived an average of 1.8 years longer. Maintaining optimal or slightly lean body condition may lower risk of developing osteoarthritis, reduce the severity of osteoarthritis, and delay onset of clinical signs of osteoarthritis in dogs.

Mobility

Other studies have shown improved mobility after weight loss among obese dogs with osteoarthritis.[16,17] In these studies, improvement was noticed after modest weight loss of at least 6% body weight.

Additional Therapy

Weight loss may have additional value for dogs when combined with rehabilitation and physical therapy. One clinical trial evaluated 29 adult dogs that were overweight or obese (BCS of 4/5 or 5/5) and had clinical and radiographic signs of osteoarthritis.[18] All dogs were fed the same diet; however, those that received intensive physical therapy, including transcutaneous electrical nerve stimulation, obtained greater weight reduction and better mobility than those that received home-based physical therapy.[18]

ANTI-INFLAMMATORY SUPPLEMENTS

Degenerative osteoarthritis involves an inflammatory component, which might be modified by the addition of nutritional components, specifically omega-3 (n-3) fatty acids, to the diet. Eicosanoids derived from n-6 fatty acids, for the most part, have vasoactive and pro-inflammatory effects. Arachidonic acid (an n-6 fatty acid) is incorporated into cell membranes and when metabolized yields prostaglandins, leukotrienes, and thromboxanes of the 2 and 4 series. Many drugs used to treat degenerative osteoarthritis inhibit conversion of arachidonic acid to these eicosanoids. Metabolism of n-3 fatty acids yields eicosanoids of the 3 and 5 series, which are less vasoactive and less pro-inflammatory. Substituting an n-3 fatty acid in the membrane may decrease these responses. In addition to modulating cytokines, n-3 fatty acids reduce expression of cyclooxygenase-2, lipoxygenase-5, aggrecanase, matrix metalloproteinases 3 and 13, interleukin-1α and -1β, and tumor necrosis factor α.[19-23] Novel oxygenated products, called resolvins (resolution phase interaction products), and docosatrienes (generated from n-3 fatty acids), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA) have been identified as resolving inflammation in exudates and tissues,[24-26] including the tissues involved in osteoarthritis.[27-32]

One study of 18 dogs with experimentally induced and surgically repaired transection of the left cranial cruciate ligament found that consumption of a high n-3 diet was associated with lower serum concentrations of cholesterol, triglycerides, and phospholipids; lower synovial concentration of prostaglandin E2; better ground reaction forces; and fewer radiographic changes of osteoarthritis compared with consumption of a high n-6 diet or a control diet.[33,34] Synovial membrane fatty acid composition mirrored the fatty acid composition of the diets consumed. Studies of dogs with osteoarthritis found associations between high n-3 diets and improved ability to rise from a

resting position and play,[35] improved peak vertical force values and subjective improvement in lameness and weight bearing,[36] and the ability to tolerate more rapid reduction of carprofen dosage,[37] compared with dogs fed control diets. A study of 48 dogs that underwent tibial plateau-leveling osteotomy for cranial cruciate ligament disease found that those fed a commercial diet with increased n-3 fatty acids had lower synovial inflammatory cytokine concentrations than did dogs fed a maintenance diet, with or without receiving postoperative rehabilitation therapy. Decreased progression of osteoarthritis was noted for dogs fed the increased n-3 diet and for dogs that underwent rehabilitation in this[38] and in another[39] study.

Dosages

Supplements given to dogs with osteoarthritis are often underdosed. Giving n-3 fatty acid supplements or feeding diets containing increased n-3 fatty acid levels to dogs with osteoarthritis is beneficial when the appropriate doses of EPA and DHA are delivered. When administering n-3 fatty acids, use the sum of EPA (a 20-carbon n-3 fatty acid) and DHA (a 22-carbon n-3 fatty acid) rather than the total amount of n-3 fatty acids. Recommended dosage is up to 175 mg of the sum of EPA and DHA per kilogram of body weight. A more accurate dosage is based on metabolic body weight: 310 mg of the sum of EPA and DHA per kilogram of body weight raised to the 0.75 power.[40] The National Research Council safe upper limit is approximately 200 mg of the sum of EPA and DHA per kilogram of body weight or 370 mg of the sum of EPA and DHA per metabolic body weight.

Initially high dosages of n-3 fatty acids often result in diarrhea. Therefore, we often start with 600 to 900 mg of the sum of EPA and DHA per kilogram of body weight for a few weeks and then increase slowly to 1200 to 1700 mg of the sum of EPA and DHA per kilogram of body weight.

Although flaxseed is often recommended as a source of n-3 fatty acids (because it contains α-linolenic acid), it is not a good source of n-3 fatty acids in dogs because dogs can convert less than 10% of α-linolenic acid to EPA.[40]

CHONDROMODULATING AGENTS

Chondromodulating agents are purported to slow or alter progression of osteoarthritis. They are used for dogs with osteoarthritis when cartilage damage is present but before fibrocartilage has developed. Beneficial effects of chondromodulating agents may include a positive effect on synthesis of cartilage matrix and hyaluronan as well as an inhibitory effect on catabolic enzymes in osteoarthritic joints.[41] These agents may also be beneficial when used prophylactically for dogs prone to osteoarthritis. Chondromodulating compounds fall into 2 categories: Food and Drug Administration-approved agents that can have label claims of clinical effects (e.g., polysulfated glycosaminoglycan) and products considered to be nutritional supplements, which legally cannot claim any medical benefits (e.g., glucosamine and chondroitin sulfate). Although many of these products are administered as supplements or alternative treatments, some (e.g., glucosamine and green-lipped mussel) are incorporated into pet foods.

Glucosamine and Chondroitin Sulfate

Glycosaminoglycans are a major component of joint cartilage and glucosamine is a glycosaminoglycan precursor; therefore, supplemental glucosamine may help rebuild cartilage.[42-48] However, data concerning the clinical effects of glucosamine-chondroitin sulfate on osteoarthritis are conflicting.[49-59] In a clinical trial comparing glucosamine hydrochloride and chondroitin sulfate with carprofen in 35 dogs with osteoarthritis, the carprofen-treated dogs showed improvement in 5 subjective measures while dogs treated with glucosamine-chondroitin sulfate showed improvement in 3 of 5 measures but only at the final assessment.[60] A 60-day trial of 71 dogs with osteoarthritis assessed subjective and objective measures comparing carprofen, meloxicam, glucosamine-chondroitin, and placebo.[61]

Beneficial effects of chondromodulating agents may include a positive effect on synthesis of cartilage matrix and hyaluronan as well as an inhibitory effect on catabolic enzymes in osteoarthritic joints.[41]

Results indicated that objectively measured variables improved significantly for dogs that received carprofen and meloxicam but not for those that received glucosamine-chondroitin or placebo. Subjective findings of veterinarians agreed with findings of objective evaluation, but subjective assessment by clients identified improvement with meloxicam only.[61] On the basis of these results, reviews have concluded that the clinical evidence of benefit of glucosamine and chondroitin sulfate in dogs with osteoarthritis is weak.[49-51]

Many dog foods formulated and marketed for adult dogs, geriatric dogs, and growing large breed dogs contain glucosamine and chondroitin sulfate, but the exact amounts are often not readily available. In terms of evaluating glucosamine and chondroitin sulfate inclusion in a manufactured dog food, questions have arisen over whether these agents are bioavailable and in enough quantity to provide benefit. These compounds are not recognized as essential by AAFCO and thus are not included in dog nutrient profiles. They are considered "generally regarded as safe" ingredients.

Green-Lipped Mussel

New Zealand green-lipped mussel (*Perna canaliculus*) is a rich source of glycosaminoglycans, although its proposed benefit is thought to be from its anti-inflammatory effects.[62] Research findings have been discrepant, possibly because of differences in product stabilization. A stabilized lipid extract more effectively inhibits inflammation than a nonstabilized extract.[63] Early studies, which used nonstabilized products, found no beneficial effect of green-lipped mussel on arthritis. By 1986, dried mussel extracts stabilized with a preservative became available, and addition of green-lipped mussel to the diet was associated with significant improvement in subjective arthritis scores,[64] reduced joint swelling and joint pain,[65] improved mobility (but not as much as dogs that received carprofen),[66] and improved clinical signs (but not musculoskeletal scores)[67] compared with dogs that received placebo. However, although systematic reviews of agents used to treat osteoarthritis in dogs found the data regarding the benefits of green-lipped mussel extract in dogs to be promising, uncertainties existed relating to the scientific quality of the data and no definitive relationship has been proven between clinical improvements and the therapy.[50,51]

In summary, 4 nutritional approaches may help prevent or treat osteoarthritis in dogs.

- Diets aimed at preventing developmental orthopedic disease may help prevent later development into osteoarthritis.
- Weight loss for overweight and obese dogs not only decreases the mechanical wear and tear on joints but decreases systemic inflammation that accompanies osteoarthritis.
- Omega-3 fatty acids (specifically EPA and DHA) beneficially modulate the inflammatory response.
- Chondromodulating agents maintain cartilage integrity and facilitate repair of damaged cartilage. TVP

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Caloric Restriction Without Malnutrition

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As of 2018, an estimated 55.8% of dogs and 59.5% of cats in the United States were overweight or obese.[1] These numbers, which are virtually unchanged from those reported in 2017, translate into approximately 1 out of every 2 dogs and cats presenting to veterinarians for wellness examinations, making obesity the most common nutritional disorder encountered in small animal practice in the United States.

Obesity and health risks associated with it (**BOX 1**) have become so prevalent that as of June 2019, 25 veterinary organizations worldwide had endorsed the Global Pet Obesity Initiative Position Statement officially classifying canine obesity as a disease.[9] Nonetheless, the veterinary profession, just like the human medical profession, continues to struggle with adequately addressing the epidemic of obesity in its patients. One key to successfully addressing this problem—effective communication with clients—is the subject of a previous *Today's Veterinary Practice* article.[10]

One concern with weight-loss programs is that use of inappropriate diets and/or levels of caloric restriction can lead to inadequate nutrient intake, resulting in nutritional deficiencies. Severe caloric restriction can also have adverse metabolic effects that work against achieving successful, safe weight loss.[11,12] This article provides guidance for calculating caloric requirements for an obesity management plan to avoid the adverse effects of severe caloric restriction, as well as for choosing an appropriate diet for weight-loss programs to avoid nutritional deficiencies.

BOX 1 Health Risks Associated With Overweight and Obesity in Dogs and Cats

Dogs and Cats
- Adverse effects on life span and quality of life[2,3]
- Lameness and osteoarthritis[2,4]
- Skin disorders[4]

Cats
- Diabetes mellitus[4]

Dogs
- Pancreatitis[5]
- Anesthetic complications[6]
- Cancer[7,8]

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CALCULATING CALORIC REQUIREMENTS FOR WEIGHT LOSS

When calculating a patient's caloric requirements for a weight-loss program, veterinarians have the choice of using the patient's current body weight (CBW) or ideal body weight (IBW). Both methods can be successful; however, there are more and more reasons to consider using CBW in most patients (**BOX 2**). (Morbidly obese patients with a high ratio of fat mass to lean mass may require a modified formula.)

Avoid Lowering Metabolic Rate

Two studies used IBW in the calculations for maintenance energy requirements (MERs) for overweight or obese dogs.[11,12] In one study, when groups of dogs were fed at 50%, 60%, 75% and 100% of their calculated MERs during a weight loss program, mean serum triiodothyronine (T_3) concentrations decreased in all dogs, with greater decreases in the more calorically restricted groups. In addition, energy requirements apparently decreased in dogs restricted to 50% or 60% of their calculated MER.[11] The second study found a similar effect on T_3 production associated with feeding overweight dogs 63% of their MER.[12] Similar effects of caloric restriction on energy expenditure have been documented in overweight and obese cats fed a moderate-protein diet as part of a weight-loss program.[13]

Thyroxine (T_4) and T_3 are major regulators of energy metabolism; therefore, a decrease in energy requirements would be consistent with a reduction in serum levels of T_3. This is referred to as the low T_3 state of undernutrition, and it is believed to protect the organism during periods of fasting or caloric restriction by lowering the metabolic rate. However, lowering metabolic rate is highly undesirable during a weight-loss program.

An additional reason for using CBW for caloric requirements during weight-loss programs is that fat is now understood to have some metabolically active tissue, and IBW underestimates the nutrient needs for fat mass that is metabolically active.[14]

Monitor and Adjust as Needed

Patients vary tremendously in the level of caloric restriction needed to achieve weight loss, so any initial calculation of caloric requirements may need to be modified based on how the patient responds. One option is to feed 80% of the patient's current caloric intake; however, this risks starting the weight loss program at a level of caloric restriction that already adversely affects T_3 production and metabolic rate. Use of CBW to calculate caloric restriction decreases this risk and provides a more patient-specific approach.

Patients should be weighed every 2 weeks to assess progress. If CBW is being used to determine caloric restriction and the client is adhering to the weight-loss plan, yet the patient is not losing weight, adjustment options include recalculating caloric requirements using the patient's new, leaner body weight; decreasing caloric intake by 10%; increasing exercise; or a combination of reduced caloric intake and exercise.

Celebrate Success

Any deliberate weight loss is good weight loss. Although the goal is to see approximately 1% body weight loss per week, if a patient is losing only 0.05% body weight per week, yet everything else is going well with the program, the patient is doing well, and the owner is satisfied, celebrate the weight loss. This will help keep the owner motivated. Wait until the patient's weight loss plateaus before modifying caloric intake.

One study in dogs showed that the extent of weight rebound strongly correlated with the rate and amount of previous weight loss.[15] Slow and steady weight loss may decrease the chances of weight rebound once the weight-loss program is completed.

CHOOSING DIETS FOR WEIGHT-LOSS PROGRAMS

Over-the-counter (OTC) maintenance diets and weight management diets should not be used for weight-loss programs. Maintenance diets are formulated to meet the nutritional needs of pets that have an IBW and are consuming a reasonable quantity of the diet based on the labeled feeding guidelines. However, the feeding guidelines on maintenance diet labels are based on CBW rather than estimated IBW. The nutrient:calorie ratio of these diets is such that if they are used to restrict calories, every other nutrient is also restricted, and nutritional deficiencies may result. Therapeutic weight-loss diets are formulated to be restricted in calories while providing adequate levels of all nutrients (detailed nutrient comparisons of dry and canned therapeutic weight-loss diets for dogs and cats are available at todaysveterinarypractice.com).

BOX 2 Obesity Management Calculation Sheet

1. Calculate resting energy requirement (RER) using current body weight (CBW).

RER = $70(BW_{kg}^{0.75})$ $70(\_\_\_\_\_ kg^{0.75})$ = kcal/day

2. Calculate obesity management energy requirement (OM).

Adult dogs: OM = 1.0(RER) = _____ kcals/day

Adult cats: OM = 0.8(RER) = _____ kcals/day

Note: *These are starting levels for kcal intake and may require modification throughout the weight loss program. Some pets may require fewer kcals than calculated here.*

3. Choose a weight loss diet.

Name of dry diet _____ = _____ kcals/cup = _____ cup(s) **twice** a day

Name of can diet _____ = _____ kcals/can = _____ can(s) **twice** a day

Note: *Cats may do better if food is left out for them to nibble on throughout the day rather than meal feeding. A specified quantity of food still needs to be offered daily, but grazing throughout the day is a more natural feeding behavior for some cats than meal feeding.*

4. Calculate treat allowance.

Maximum treat kcals = 10% of RER = 0.1(RER) = _____ kcals

Name of treat _____ = _____ kcals/treat

Treats per day = Maximum treat kcals _____ / _____ kcals/treat = _____ treats

Note: *Treats should be limited to <10% of total kcal intake/day.*

5. Calculate rate of weight loss.

Rate = 0.01(CBW) = _____ pounds lost per week

Note: *The preferred rate of weight loss is 1% of body weight per week. Please weigh the pet once every 2 weeks. If patient is not losing weight, decrease caloric intake by 10%.*

Exercise is strongly encouraged! The most successful weight-loss programs combine caloric restriction with exercise. Start any exercise program slowly.

How can you tell when a pet has achieved an optimal weight? When the pet has reached an ideal body condition score. Pet owners can be taught an abbreviated version of how to perform a body condition score:

■ They should be able to feel ribs but not see them when the pet is standing.

■ The pet should have an hourglass figure when viewed from top. If the pet has a thick hair coat, it is important to rely on hands-on assessment, not visual assessment.

Note: *This sheet is intended to be a quick guide when creating a weight loss plan for patients. If reproducing this sheet to give to the owner, modify as desired.*

A recent study evaluated whether nutrient deficiencies may exist when veterinarians use top-selling commercial OTC adult maintenance diets or weight management diets at progressive levels of caloric restriction in dogs.[16] This study showed that when MER calculations are done using CBW with a MER formula recommended by the National Research Council for dogs with low energy intakes, 2 of 31 commercial dry diets were at risk of nutrient deficiencies when fed at 100% MER. The risk of deficiencies increased with the level of caloric restriction. When diets were fed at 60% MER, 1 diet had 3 nutrients at risk of deficiency, while the remaining 30 diets had more than 3 nutrients at risk of deficiency. The nutrients most commonly at risk of deficiency were choline, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), methionine, cysteine, riboflavin, pantothenic acid, cobalamin, selenium, cholecalciferol, vitamin A, folic acid, thiamin, and tryptophan. Had the authors used IBW when calculating MER instead of CBW, more potential nutritional deficiencies would no doubt have been seen.

KEY NUTRIENTS IN THERAPEUTIC WEIGHT-LOSS DIETS

Using a therapeutic weight-loss diet during a weight-loss program reduces the risks of nutritional deficiencies because the levels of key nutrients in these diets have been adjusted to be adequate despite low caloric density (the levels of key nutrients in various therapeutic weight-loss diets are available at todaysveterinarypractice.com). Some diets also contain additional nutrients that are beneficial during weight-loss programs. There is enough variation among therapeutic weight-loss diets that if one is not effective, it may be worth trying a different one.

Protein

Several studies have suggested that a higher protein: calorie ratio than that found in many OTC maintenance diets is necessary for preservation of lean body mass during weight loss.[13,17] Maintenance of lean body mass is an important component of successful weight loss, and it may help maintain energy expenditure and lessen the risk of weight rebound.

Preservation of lean body mass may also help maintain the patient's protein turnover rate, which facilitates rapid redistribution of amino acids to support immediate synthesis of proteins essential for life. Reduced protein turnover from inadequate protein intake can lead to decreased immune competence and increased susceptibility to stresses such as infection and injury.[18] It is also very important that patients receive adequate amounts of essential amino acids during a weight-loss program.

Higher dietary protein intake may also have an effect on satiety.[19] The enhanced feelings of satiety associated with ingestion of dietary proteins may be related to induced thermogenesis, hormonal regulation, slower passage rate from the stomach as a result of release of cholecystokinin (CCK), and sensorial experience during food consumption. In dogs, higher protein intake in combination with higher fiber intake has a greater impact on satiety than either high protein intake or high fiber intake alone.[17] In cats, the situation is more complex. A high protein:calorie ratio promotes loss of body fat while helping to maintain lean body mass;[20] however, satiety in cats is best induced when dietary protein and fiber are moderately rather than markedly supplemented.[21]

Fat

Dietary fat also causes the release of CCK; however, most therapeutic weight-loss diets are restricted in fat to reduce the energy content. Fat has more than twice the energy density of protein or carbohydrates (9.0 kcal/g versus 4.0 kcal/g). However, as with protein intake, the intake of fat must ensure that adequate levels of essential fatty acids are being provided.

Total Dietary Fiber

Total dietary fiber (TDF) is different than percentage of crude fiber (%CF), which is required to be listed on the guaranteed analysis on pet food labels. Crude fiber percentage is an estimate for only insoluble fiber content and underestimates the true fiber content of the diet, whereas TDF accounts for both insoluble and soluble fiber content. Having soluble fibers in the diet is important because many soluble fibers are also moderately fermentable fibers, which provide nutrients for the beneficial bacteria in the gastrointestinal tract, and fermentation of moderately fermentable fibers by beneficial bacteria produces short-chain fatty acids, which are a major fuel source for colonocytes.

A higher fiber content also allows a larger volume of food to be fed to the patient without adding significant calories to the diet.

Anti-inflammatory Nutrients

Obesity is a chronic inflammatory disease and has been shown to be a risk factor for developing osteoarthritis (OA) in dogs.[22] Therefore, diets that contain nutrients that help reduce inflammation and clinical signs associated with OA, such as EPA and DHA, may be desirable to feed during a weight-loss program.[23] Not all dogs or cats with OA show obvious radiographic evidence of it, and OA in cats is more likely to go underdiagnosed than in dogs.[24] Therefore, providing nutrients in the diet to reduce inflammation and address possible OA may be an important component in therapeutic weight-loss diets.

L-Carnitine

L-carnitine facilitates the transport of fatty acids from the cytoplasm into the mitochondria, where they help to generate energy. Dietary L-carnitine supplementation has been shown to aid in preserving lean body mass during weight loss in dogs.[25] In overweight cats, dietary supplementation with L-carnitine during weight loss resulted in a higher resting energy expenditure-to-lean body mass ratio than in cats not receiving the supplementation.[26] In another study evaluating rapid weight loss in obese pet cats, the group that received a diet supplemented with L-carnitine lost weight more rapidly than the group consuming a diet not supplemented with L-carnitine,[27] while another study showed cats fed diets supplemented with L-carnitine lost more weight than cats not receiving supplemental L-carnitine.[28]

The levels of supplemental L-carnitine used in weight-loss studies in dogs have varied, but most published studies have used a 300 mg/kg diet on a dry matter basis. The levels of supplemental L-carnitine used in studies in cats have also varied, with levels of 250 mg per day per cat being most common. However, a recommendation of at least 500 mg/kg diet on a dry matter basis has also been suggested for cats.[29]

Additional Beneficial Nutrients

Some diets contain additional nutrients that have been shown to be beneficial for weight-loss programs in dogs and cats (visit todaysveterinarypractice.com). Hill's Pet Nutrition has a proprietary blend of synergistically effective nutrients in some of its therapeutic weight-loss diets for dogs and cats that works at the cellular level to change gene expression affecting metabolism.[30-32] Nestle Purina PetCare has added isoflavones to some of its canine therapeutic weight-loss diets. These soy germ isoflavones have been shown to enhance energy metabolism in dogs while reducing body fat accumulations and to help reduce the risk of weight rebound.[33]

Dietary L-carnitine supplementation has been shown to aid in preserving lean body mass during weight loss in dogs.[25]

THE ROLE OF TREATS IN WEIGHT LOSS PROGRAMS

It is common practice for veterinarians to eliminate treats as part of a pet's weight-loss program.[16] However, if giving treats is an important part of the daily interaction between the owner and pet, it is important not to disrupt the human-animal bond. Successful weight-loss programs rely on owner motivation and actions, and if the owner feels guilty that the pet is not allowed to have treats, they may be less likely to stick with the program, or may still give treats but not admit to doing so.

Any weight-loss program should have both short-term and long-term goals. The short-term goal is to attain an appropriate amount of weight loss during the weight-loss program to achieve an ideal body condition. The long-term goal is to have the pet keep the weight off after the program is completed. Therefore, it is important for any weight-loss program to instill habits in owners that they will follow long-term. Owners who like to give treats to their pet should be allowed to do so, but should be given options of low-calorie treats to use and cautioned to limit the amount of treats to less than 10% of the pet's total caloric intake.

KEY POINTS

- Nutrient deficiencies can develop in patients undergoing a weight-loss program because of use of inappropriate diets and/or levels of caloric restriction that result in inadequate nutrient intake.
- Over-the-counter maintenance diets and weight

management diets should not be used for weight-loss programs.

- Therapeutic weight loss diets are formulated to be restricted in calories while providing adequate levels of all nutrients.
- Treats can be given during a weight-loss program, but providing low-calorie options and limiting quantities are important. TVP

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Evaluating Fresh Diets in Practice

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Dietary trends for dogs and cats closely mirror those of their owners, and it is no surprise that home-prepared meals and their commercialized derivatives are now encountered in practice. These diets pose potential benefits as well as challenges, and clients increasingly expect veterinarians to demonstrate knowledge of them.

WHAT IS A FRESH DIET?

Fresh diets are broadly defined as diets that are not shelf-stable at room temperature, such as:

- Home-prepared cooked diets
- Home-prepared raw diets
- Commercial made-to-order diets (generally cooked and provided refrigerated)

Some owners consider fresh diets to be only those prepared in a certain window of time before feeding. The following diets therefore may or may not be considered "fresh":

- Commercial premixes (cooked or raw ingredients are added by the owner)
- Commercial refrigerated diets (raw or cooked)
- Commercial frozen diets (raw or cooked)

WHY DO OWNERS FEED FRESH DIETS?

Pet owners increasingly select diets based on an assessment of ingredient quality and sourcing, safety and transparency, and customization and variety.[1,2] Fresh diets, especially home-prepared diets, are uniquely positioned to allow this assessment and permit owner choice. Other motivations for feeding these diets are diverse, including the factors below.[3-8]

Distrust of Commercial Pet Foods

Consumer distrust is primarily driven by recalls, of which there were more than 40 in 2018[9] for issues such as elevated vitamin D levels, low thiamine (vitamin B1), and contamination with *Salmonella* or *Listeria* bacteria. Many owners cite the melamine recalls after significant numbers of dogs and cats developed acute kidney injury.[10,11] This distrust in commercial options was identified in 51% of dog owners in an oncology service, and 67% of raw-feeding owners displayed similar sentiment.[12,13]

Ingredient Quality

Owners now evaluate ingredients on a number of potential metrics, such as sustainability, animal welfare, organic standards, and growing region. Visual

assessment of ingredients remains important to consumers, and extruded kibble or homogenized canned food does not readily permit this. Some owners cite reports of unlabeled ingredients.[14] Others distrust synthetically derived vitamins and minerals, which are exempted from Association of American Feed Control Officials (AAFCO) regulations for natural foods and may be sourced from outside the United States.[15]

Skepticism Regarding Current Nutritional Guidelines

The basis for "complete and balanced" pet foods is the available nutritional literature, which is limited for some nutrients and was often gathered under experimental conditions with extruded or purified diets.[15,16] Owners feel that dogs fed unbalanced fresh diets—that is, diets not conforming to current recommendations—show no outward signs of disease and that present knowledge is incomplete to set thresholds for some nutrients. It is true that some nutrient minima may be inaccurate and some deficiencies or excesses affect health more than others.[16,17]

Palatability

Many owners report that their dogs only eat (or strongly prefer) fresh foods. This anecdotally appears more prevalent in small dogs. Improved palatability is likely influenced by a combination of factors, such as increased moisture, protein, fat, aroma, and even the owner's perception.[18,19]

Preservative Avoidance

Synthetic preservatives such as ethoxyquin, BHA, BHT, and TBHQ were historically used in commercial pet foods given their effectiveness, but controversies still surround their safety.[7,20] Natural preservatives, such as tocopherols, rosemary extract, and citric acid, are now commonly used, but fresh diets may reduce or eliminate the need for preservatives.

Customization or Rotation

Home-prepared diets allow owners to change protein and carbohydrate sources readily. Many commercial fresh diets provide diets with similar nutrient composition but different ingredients. Dietary rotation of any type certainly allows for greater nutrient variability, which may confer health benefits and may mitigate suboptimal nutrient levels for a particular animal.

Specific Health Conditions or Concerns

Fresh diets are commonly used in the management of hyporexic pets with renal disease, gastrointestinal disease, or cancer.[12,21-23] Home-prepared fresh diets have been recommended for the diagnosis and management of adverse food reactions.[24] Such diets may also be used by owners of sporting or working dogs with the thought of improving performance or providing supplemental protein, fat, or calories; sled dogs are commonly fed a hybrid diet of commercial foods and raw meat, and racing greyhounds may be fed raw foods.[25,26] Fresh diets may affect the microbiome differently than extruded diets, which could influence gastrointestinal or overall health, and they are often highly digestible.[27,28] Clients may choose fresh diets in the hopes of preventing disease by promoting health.[2]

> Pet owners increasingly select diets based on an assessment of ingredient quality and sourcing, safety and transparency, and customization and variety.[1,2]

Raw Food Claims

A number of specific claims about raw food are discussed in greater detail elsewhere.[28,29] There is insufficient evidence that a raw diet is superior to the same diet when cooked.

HOW COMMON ARE HOME-PREPARED AND COMMERCIAL FRESH DIETS?

The overall prevalence of home-prepared diet use among pet owners remains unclear, but 3 studies have provided limited data:

- In one study, home-prepared diets were fed as the sole source of nutrition to 2% to 3% of dogs and 0% of cats in the general population, but noncommercial foods provided at least 25% of the diet for 17% of dogs and 6% of cats.[30]
- In another study, breeders fed home-prepared diets to 11% of dogs across all life stages, and the practice was more common in giant-breed dogs.[31]

- In the third study, 7% percent of owners with dogs presenting to an oncology service fed home-prepared cooked diets, 4% fed prepared raw diets, and 18% fed a combination of diets, including a home-prepared diet.[12]

Commercial fresh diets represent millions in annual sales, with most companies targeting healthy animals.[32] Some fresh food companies now offer therapeutic diet lines (both cooked and raw) intended for veterinary supervision and sold through established retail channels or, increasingly, shipped directly to the owner.[2] The market share of fresh diets is expected to increase.

PROBLEMS WITH HOME-PREPARED DIETS?

When severely unbalanced, home-prepared diets have been implicated in clinically significant pathology, including:

- Nutritional secondary hyperparathyroidism. The absence of calcium in the diet of growing puppies has caused fibrous osteodystrophy and other skeletal abnormalities.[33-35] Low dietary vitamin D is often concurrently identified. The condition is rare in adult dogs but has been documented.[36,37]
- Thiamine deficiency[38]
- Electrolyte abnormalities[34]
- Taurine deficiency, a cause of dilated cardiomyopathy[34,36,39]

Adverse effects are likely underreported, as dietary change frequently corrects discovered abnormalities.

Owners appear to infrequently consult recipes for their home-prepared diets, but recipes are available on the internet and in print from veterinary and non-veterinary sources.[30,40,41] Such recipes often lack specificity, which could affect nutrient composition, and owners often change recipes without guidance.[21,22,41] A few evaluations have compared recipes to nutritional recommendations, with the following findings:

- 95% of maintenance diets did not meet recommendations for at least one essential nutrient, diets from non-veterinary sources were more deficient, and rotational strategies were unlikely to balance diets.[41]
- 90% of tested home-prepared diet recipes provided by veterinarians for food allergy did not meet nutrient recommendations.[24]
- 100% of renal diets and diets suggested for cancer failed to meet recommendations.[21,42]

The impact of the deficiencies identified in the above studies would be expected to range in severity. Nutrients that were commonly identified as being below established recommendations included:

- Amino acids, specifically methionine, tryptophan, and phenylalanine[21,42]
- Calcium[21,41,43]
- Zinc[21,41]
- Vitamin D[41-43]
- Choline[21,41,42]

Insufficient amino acids could adversely affect muscle mass, produce taurine deficiency, or contribute to poor coat quality. Inadequate vitamin D and calcium could influence bone development in growing animals, and zinc plays a role in skin and immune function. Choline may be spared by other nutrients in the diet but plays a role in lipid handling and methyl group donation.[16] Clinical signs of nutrient deficiency are often present only when severe, making assessment in the clinic difficult. Some deficiencies require special screening laboratory tests (ionized calcium, parathyroid hormone levels, vitamin D testing, amino acid levels).

HOW CAN HOME-PREPARED FRESH DIETS BE IMPROVED?

Two important recommendations should be made to owners committed to preparing their own diets:

1. Offer referral to a board-certified veterinary nutritionist for evaluation and reformulation of the diet. A list of diplomates available for consultation is available at acvn.org, and the estimated cost of diet formulation ranges from $150 to $500. An alternative is a computer-generated recipe conforming to nutrient guidelines (e.g., balanceit.com).
2. Advise the owner to consider a commercially available fresh diet with an AAFCO statement for the appropriate life stage.

If an owner declines the above options, the following questions can help screen diets for the most commonly encountered sources of dietary deficiencies. Owners should be counseled that most diets from internet sources and other recipes fail to meet established nutrient recommendations, and puppies and kittens should always have a referral or be fed a commercial food given their more critical nutrient tolerances.

1. **Is the diet composed primarily of meat (50% or**

more by weight)? Dogs and cats have no requirement for dietary carbohydrate but do have requirements for amino acids and fatty acids that are often lower in vegetable sources. Contraindications to such a diet should be considered (e.g., renal disease, canine pancreatitis).

2. **Is supplemental calcium added to the food?** Most meats are high in dietary phosphorus but low in calcium. The following doses can be used as general guidelines:
   - **Adult cats:** 0.4 g calcium daily = ⅓ teaspoon of calcium carbonate
   - **Adult dogs:** 2 g calcium per 1000 calories (the amount of food consumed by an average 50-pound pet dog) = 1⅔ teaspoon of calcium carbonate

   Diets containing bones or bone meal likely contain both calcium and phosphorus, but the amounts may be excessive, especially for large-breed puppies. These minerals and other macronutrients can be measured in a sample of the food by a commercial feed laboratory.
3. **Is there a multivitamin product in the recipe?** Once-daily human multivitamins are preferred over pet multivitamins, unless the latter is specifically designed, evaluated, or endorsed by a nutritionist for use in balancing home-prepared diets. Many common pet vitamins contain minimal quantities of essential nutrients. Once-daily human multivitamins are typically dosed at about ¼ tablet per 25 pounds of patient body weight.

   Organ meats are used in some diets to provide trace vitamins and minerals, but their adequacy in fulfilling the nutrient needs of a dog or cat can be difficult to evaluate based on weight of inclusion or percentage of the recipe without specific analysis.
4. **Are there supplemental fatty acids in the diet?** Most diets benefit from supplemental EPA and DHA (omega-3 fatty acids) unless the diet contains large amounts of fish (e.g., tuna, salmon). A dose of 300 mg of EPA and DHA combined (1 standard fish oil capsule) per 25 pounds of body weight is generally sufficient for maintenance purposes. Most prepared diets naturally contain adequate amounts of linoleic acid, an essential omega-6 fatty acid.

The above recommendations do not ensure nutritional adequacy for every condition or every animal, but do help to prevent the most significant deficiencies identified in diets. If owners elect to use a commercial premix, the product should be evaluated for sources of vitamins and minerals, such as calcium or bone meal, individually named vitamins and trace minerals, and/or dried organ meats.

HOW SHOULD COMMERCIAL FRESH DIETS BE EVALUATED?

Fresh diets should be evaluated similarly to all commercial pet foods.[3,28,44] Suggested metrics for evaluation include:

- **Does the product provide an AAFCO statement for the appropriate life stage of the patient?** Products labeled for intermittent or supplemental feeding should not be fed long-term without veterinary guidance, nor should products without an AAFCO statement.
- **Has the diet been analyzed to confirm the nutrient levels provided, and is a detailed nutrient profile on a caloric basis available?** Ideally, foods that are formulated to meet requirements are also tested for confirmation of expected values, which is not a statutory requirement. Feeding trials may be performed, but such trials typically only identify major deficiencies. Foods should always be compared on a caloric basis.[45]
- **Who formulated the diet, and what are their qualifications?** Ideally, diets would be formulated or reviewed by a nutritionist (PhD or board-certified DVM) with experience in the type of food being produced.
- **Does the company operate its own manufacturing facility?** Companies producing their own food are expected to maintain more control over the process, but this has not been objectively evaluated.

Fresh foods, by nature, are more perishable than extruded or canned diets. Therefore, owners should be encouraged to ask additional questions regarding food quality and safety:

- **How is the food best stored, and how is temperature controlled during storage and shipping?** Fresh foods are susceptible to increased bacterial growth and oxidation if exposed to temperature fluctuations.
- **How are the ingredients sourced?** Owners may have additional questions relating to their preferred evaluation rubric for ingredients.
- **What safety and quality measures are present in the manufacturing facility?** A comprehensive food safety protocol should be followed to reduce the potential for contamination. This should include routine testing for pathogens such as *Salmonella* and *Listeria*, the latter of which can reproduce under

refrigerated conditions.[46]

- **What strategies are used to control bacterial growth and pathogens?** Raw foods contain higher bacterial concentrations than extruded diets if untreated, but so do many fresh cooked products. Pasteurization and pH-adjusting inclusions (such as acetic and citric acids) can reduce bacterial numbers.[28,47] Bacteriophages appear to be in use by at least one company, but there is controversy over the regulatory status of this approach.[48]

FRESH DIETS ARE THE NEW REALITY

Current recommendations are that all patients should receive a screening nutritional assessment.[49] Consumer demand and market forces indicate that home-prepared and commercial fresh diets will be increasingly encountered during this assessment. Knowledge of the diversity of options in this group of diets, as well as their merits, will help practitioners provide the best evidence-based guidelines to clients, match recommendations to the motivations of the owner, and support the specific nutritional needs of the patient. TVP

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