Chapter 27

Obesity

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"If we could give every individual the right amount of nourishment and exercise, not too little and not too much, we would have found the safest way to health."
Hippocrates

CLINICAL IMPORTANCE

Obesity is a real disease and is thought to be the most prevalent form of malnutrition in pets of westernized societies. Large studies in Great Britain and the United States indicate that the prevalence of overweight and obese dogs is between 24 to 30% (Lund et al, 2006; Armstrong and Lund, 1996; Mason, 1970; Meyer et al, 1978; Edney and Smith, 1986). Similar studies indicate the prevalence of overweight and obesity in cats is between 25 to 35% (Lund et al, 2005; Armstrong and Lund, 1996; Scarlett et al, 1994). Being overweight appears to be more problematic in middle-aged dogs and cats; 42% of dogs and 44% of cats between the ages of five and 11 years are overweight in the United States (Lund et al, 2005, 2006).

Deciding when a given animal is in ideal, overweight or obese body condition has clinical relevance because overweight and obesity may adversely affect an animal's health. By definition, obesity is the accumulation of excess body fat. Body weight increases as fat accumulates; thus, having excessive body fat and being overweight are related. Although body weight can increase for multiple reasons (Burkholder and Toll, 2000), the majority of overweight dogs and cats have excess body fat.

Body weight relative to an animal's optimal (ideal) weight has been used as a defining criterion for obesity because body weight is easier to measure than body fat. Relative body weight (RBW) is simply an animal's current weight divided by its estimated optimal weight. People are defined as mildly obese when actual body weight exceeds optimal body weight by 15 to 30% (NIH, 1985, 1998; Owen, 1988). Similar definitions have been proposed for dogs and cats (Joshua, 1970; Lewis et al, 1987). Arbitrary ranges for RBWs for overweight dogs and cats are between 10 and 20% above optimal weight. Obese dogs and cats are characterized by RBWs above 20%.

Fat mass, expressed as a percentage of body weight, can also be used to define obesity. People are considered obese when percent body fat (%BF) exceeds 20 to 30% of total weight (NIH, 1985; Owen, 1988). Body composition studies of dogs and cats indicate that animals judged to be in ideal body condition have 15 to 20% body fat (Stanton et al, 1992; Laflamme et al, 1994, 1995; Burkholder, 1994; Laflamme, 1997, 1997a).

Health Risks of Obesity

Excessive deposition of body fat has detrimental effects on health and longevity. In people, these detrimental effects begin, and thus obesity has been defined, when body fat exceeds 20 to 30% of body weight (NIH, 1985; Lew and Garfinkel, 1979).

Even being moderately overweight throughout life reduces lifespan. In a lifelong study of two groups of Labrador retriever dogs, the treatment group was fed 25% less than the control group (Kealy et al, 2002). Over the course of the study, the control group became moderately overweight. The median lifespan of the leaner group was 13.0 years compared to 11.2 years for the moderately overweight dogs. Many pet dogs and cats are

Table 27-1. Diseases associated with or exacerbated by obesity.

Metabolic alterations
Anesthetic complications
Dyslipidemia or hyperlipidemia
Glucose intolerance
Hepatic lipidosis (cats)
Insulin resistance
Endocrinopathies
Diabetes mellitus
Hyperadrenocorticism
Hypopituitarism
Hypothalamic lesions
Hypothyroidism
Insulinoma
Pituitary chromophobe adenoma
Functional alterations
Decreased immune function
Dystocia
Exercise intolerance
Heat intolerance
Hypertension
Osteoarthritis/joint stress/musculoskeletal pain
Respiratory distress or dyspnea
Other diseases
Altered kidney function
Cardiovascular disease
Dermatopathy
Neoplasia
Oral disease
Pancreatitis
Transitional cell carcinoma (bladder)
Urinary tract disease (cats)

Table 27-2. Selected adipocyte secretory products (fat-derived peptides).*

Adiponectin	Leptin
Angiotensinogen	Plasminogen activator inhibitor-1
Complement protein 3	Resistin
Insulin-like growth factor-1	Serum amyloid A
Interleukin β	Transforming growth factor β
Interleukin 6	Tumor necrosis factor

*Adapted from Coppack SW. Proinflammatory cytokines and adipose tissue. Proceedings of the Nutritional Society 2001; 60: 349-356. Gayet C, Bailhache E, Dumon H, et al. Insulin resistance and changes in plasma concentration of TNFα, IGF1, and NEFA in dogs during weight gain and obesity. Journal of Animal Physiology and Animal Nutrition (Berlin) 2004; 88: 157-165. Miller D, Bartges J, Cornelius L, et al. Tumor necrosis factor-α levels in adipose tissue of lean and obese cats. Journal of Nutrition 1998; 128 (Suppl.): 2751S-2752S. Trayhurn P. Inflammation in obesity: Down to the fat? Compendium on Continuing Education for the Practicing Veterinarian 2006; 28 (Suppl. 4): 33-36.

overweight to this degree (Lund et al, 2005, 2006).

Numerous diseases are associated with obesity (Laflamme, 2006). **Table 27-1** lists abnormalities associated with or exacerbated by obesity. Potential common threads exist between excess body fat and many of these diseases including cytokines, hormones and oxidative stress. A growing body of evidence suggests that body fat is no longer thought of as simply an energy storage depot. Adipocytes produce and secrete numerous cytokines and hormones, sometimes collectively referred to as fat-derived peptides (**Table 27-2**) (Trayhurn, 2006; Gayet et al, 2004; Coppack, 2001; Miller et al, 1998). Many of these fat-derived peptides are proinflammatory and probably are important in several of the diseases discussed below. Thus, obesity is likely a chronic, low-grade inflammation affecting many body systems.

Other studies show that obesity increases oxidative stress. The consequences of prolonged oxidative stress to cell membranes, proteins and DNA have been associated with cancer, diabetes mellitus, urinary tract disease, heart disease and liver disease (Tanner et al, 2006; Sonta et al, 2004; Urakawa et al, 2003; Ha and Le, 2000; Thamilselvan et al, 2000; Kesavulu et al, 2000; Freeman et al, 1999; Cheng et al, 1999; Center, 1999; Knight, 1999; Ames et al, 1993).

Obesity in people is closely associated with insulin resistance, type 2 diabetes mellitus, hypertension, hyperlipidemia and cardiovascular disease. In 1999, the World Health Organization (WHO) clustered these ailments and characterized the condition as metabolic syndrome. Metabolic syndrome was defined as impaired glucose tolerance/insulin resistance with two or more of the following: elevated blood pressure, obesity (body mass index [BMI] >30), reduced high-density lipoprotein cholesterol, high triglyceride concentrations and microalbuminuria. Although metabolic syndrome has not been identified in dogs and cats as defined by the WHO, they are prone to many diseases that have been linked to and are associated with obesity.

Similar to findings in people, obese dogs and cats have increased risk of dyslipidemia (high triglycerides and cholesterol). Obese dogs and cats have elevated levels of triglycerides, cholesterol and altered lipoprotein profiles (Yamka et al, 2006; Yamka and Friesen, 2006; Jeusette et al, 2004, 2005; Sunvold and Bouchard, 1998). As in people, cholesterol and triglyceride levels decrease in dogs undergoing weight loss (Diez et al, 2004). Note that in these studies, although triglyceride and cholesterol levels were elevated, both were still within normal published ranges.

Obese dogs have an increased prevalence of cardiovascular disease in the form of congestive heart failure (Edney and Smith, 1986). Increases in blood pressure have been documented to occur in dogs under experimental conditions immediately after increases in body weight (Rocchini et al, 1987, 1989; Buffington, 1994). Structural changes in the heart have been documented in as little as nine weeks in obesity-related hypertension in dogs. Pathology included marked changes in the right atrium and left ventricle (Philip-Couderc et al, 2003). The liver and adipose tissue produce the peptide angiotensinogen (**Table 27-2**). The strong correlation between obesity and hypertension implies that excess adipose tissue may play a direct role in blood pressure regulation (Frederich et al, 1992).

Grossly obese dogs have an increased prevalence of traumatic and degenerative orthopedic disorders (Edney and Smith, 1986). Furthermore, the severity of osteoarthritis is greater in dogs with body condition scores (BCS) above ideal. Also, the mean age at which 50% of dogs required long-term treatment for osteoarthritis was significantly younger (10.3 years) in mod-

erately overweight dogs compared to dogs with normal BCS (13.3 years) (Kealy et al, 2002). In addition to increased mechanical stress on joints resulting from excess body weight, the associated body fat produces several inflammatory mediators (Eisele et al, 2005; Trayhurn and Wood, 2004) that could contribute to, or conceivably cause, osteoarthritis (Sowers et al, 2002). In a study that investigated multiple biomarkers for early indicators of disease, obese dogs had significantly higher levels of alkaline phosphatase and type 2 cartilage synthesis indicating increased risk for osteoarthritis (Yamka et al, 2006).

Obesity has also been reported to predispose dogs and cats to diabetes mellitus or exacerbate this illness (Mattheeuws et al, 1984, 1984a; Nelson et al, 1990; Nelson, 1990; Panciera et al, 1990). Certain of the hormones and inflammatory mediators produced by adipose tissue (**Table 27-2**) are thought to play a role (Plomgaard et al, 2005). For example, adiponectin is a non-cytokine, fat-derived peptide and is the only one protective against inflammation. Unlike most fat-derived peptides, circulating levels are inversely proportional to obesity; low levels of adiponectin cause insulin resistance (Pischon et al, 2004). Another fat derived peptide, resistin, is up-regulated in obesity. Increased resistin levels participate in the pathogenesis of insulin resistance (Muse et al, 2004; Steppan et al, 2001). Also, overweight dogs have increased levels of tumor necrosis factor-α, insulin-like growth factor-1 and glucagon-like protein-1; all of these peptides have been associated with insulin resistance (Gayet et al, 2004; Yamka et al, 2006).

Obesity is a predisposing factor to idiopathic hepatic lipidosis in anorectic cats (Armstrong, 1989; Biourge et al, 1994). A less well-documented effect of obesity in dogs and cats is an increased risk for anesthetic complications, a belief held by many veterinary practitioners (Clutton, 1988). Decreased heat tolerance and stamina are also purported consequences of obesity in dogs and cats (Anderson and Lewis, 1980; Edney, 1974). Other health problems thought to be associated with or exacerbated by obesity include dyspnea, dystocia, dermatologic problems and reduced immune function, although the association between obesity and these clinical effects is less than definitively documented (Buffington, 1994; Newberne, 1966; Williams and Newberne, 1971). Oral disease and urinary disease have also been linked to obesity (Lund et al, 2005). **Table 27-1** lists abnormalities associated with or exacerbated by obesity.

Overweight and obesity in people, dogs and cats are strongly associated with an increased risk for urinary stone formation. Overweight dogs have twice the risk for developing uroliths (Lekcharoensuk et al, 2000). Overweight cats have nearly three times the risk of calcium oxalate urolithiasis compared to lean cats (Lekcharoensuk et al, 2001). In people, this correlation is reported to be due to increased urinary excretion of promoters, but not inhibitors of calcium oxalate urolith formation. Also, a significant positive relationship was shown for BMI and urinary excretion of uric acid, sodium, ammonium and phosphate. An inverse correlation was shown between BMI and urinary pH (Siener et al, 2004).

An indirect relationship between obesity and cancer has been reported to occur in overweight dogs. A case control study was conducted to determine if exposure to secondhand cigarette smoke, household chemicals and topical insecticides was associated with transitional cell carcinoma of the urinary bladder. Bladder cancer risk was unrelated to cigarette smoke or household chemicals but was significantly increased by topical insecticide use, depending on the number of applications per year. This risk was enhanced in overweight and obese dogs (Glickman et al, 1989).

PATIENT ASSESSMENT

The assessment goals for overweight and obese patients should be to: 1) review the medical record for associated concurrent health issues, 2) conduct a thorough feeding assessment and 3) determine the degree to which the patient is overweight or obese. Attaining these goals is central to the development of an effective feeding plan for weight management.

History and Physical Examination

Medical Record Review

A review of the medical record provides objective historical information and documents the pet's previous health status and whether the pet is currently receiving any medications that might be associated with an overweight or obese condition.

Obesity can be a clinical sign accompanying the endocrinopathies listed in **Table 27-1**. Hyperadrenocorticism, hypothyroidism and diabetes mellitus are the endocrinopathies most amenable to treatment. In these cases, obesity is caused by the physiologic alterations resulting from hyperadrenocorticism and hypothyroidism. Although hypothyroidism is commonly associated with obesity in dogs, hypothyroidism is not a common cause of obesity. The prevalence of hypothyroidism in dogs is only 1% (Chastain and Panciera, 1995). No more than one-fourth of hypothyroid dogs are obese, whereas the prevalence of obesity in dogs is 25% (Chastain and Panciera, 1995). Obesity may either cause or occasionally result from diabetes mellitus. In either case, weight loss in an obese diabetic will improve the chances for better regulation of blood glucose concentrations and perhaps decrease or eliminate the need for insulin administration to achieve glycemic control (Chapter 29).

Treatment of the remaining endocrinopathies in **Table 27-1** is often unrewarding. They are listed for completeness and reference, and should be considered after the more common diagnoses are excluded and when patients do not lose weight with even the most severe caloric restriction. A veterinarian presented with an obese patient should use historical information and physical and clinical pathologic findings to include or exclude the possibility of a systemic problem causing or contributing to the obesity.

Current Feeding Plan Assessment

A thorough feeding assessment should be conducted, particularly in regards to food intake, physical activity and changes in body weight. The food history should include the name of the

Box 27-1. Feeding History and Food Records.

A quantitative food record can provide important information for use in a weight-loss program. Knowledge of total calories being consumed can be used to determine the amount to feed for weight loss. The process of a pet owner providing a feeding history to a veterinary health care team can help with compliance to a weight-loss program by making pet owners aware of all the sources of calories that could conceivably contribute to the pet's overweight condition.

The food record should include amounts of all foods and account for all calories the patient consumes. Caloric content of commercial pet foods and treats can be obtained from the manufacturer or calculated (Chapter 1). Tables 13-4 (dogs) and 20-4 (cats) list caloric content for several commercial foods. Most packaged human foods include caloric content on the label. The clinical cases at the end of this chapter demonstrate the utility of a quantitative food record for determining appropriate amounts of food for achieving weight loss.

The owner's quantitative descriptions of how much pet food, how many treats and access to table food and consumable chew toys must be evaluated. Terms such as "bowls," "cups" and "handfuls" reported by owners come in all sizes; thus, the amount of food and calories these objects can hold varies as well. The veterinary nutritionist's "cup" is a standard 8-oz. volume measure. The amount of dry dog or cat food reportedly fed by owners needs to be converted to this standard or to weight (as fed) for accurate determination of caloric intake. Treats, consumable chew toys and table food can supply significant calories, especially if the owner is unaware of their caloric content or how many the animal eats daily.

Whether the pet has access to any other sources of food also needs to be determined. Other sources include other pets' food in multi-pet households. Having multiple people feed the pet can result in multiple sources of food, particularly if different people have different opinions about the body condition of the pet. The previous two situations can condemn a weight-reduction program to failure before it ever begins if the owner cannot, or will not, feed the overweight pet separately and keep the overweight pet from eating other pets' food. Dogs and cats that roam unsupervised also have the opportunity to obtain other sources of food.

If an owner insists on feeding treats to a pet entering a weight-loss program, the number can be controlled by placing a specific quantity of treats containing the number of calories reserved for treats in a "treat container" each day. No additional treats are allowed for that day after the treat container is empty.

food, its form and how much is fed. Also, it should be determined whether commercial treats and/or table foods are fed and if so, how much. Accurate accounting of the total amount of food (calories) fed can be very important in the development of a feeding plan for weight loss (**Box 27-1**). It is also important to know what feeding methods are used for the pet and who feeds and/or provides treats. Most owners supplement their pets' food regimen with treats and/or table foods (Buffington et al, 2004).

Determining the Degree of Overweight and Ideal Body Weight

Determining whether a cat or dog is overweight is usually not difficult. However, accurately determining the degree of overweight and the patient's ideal weight can be challenging. In the clinical setting, the subjectivity inherent in determining the degree of body fat makes irrefutable, objective measurement difficult. This subjectivity results from variation in body conformation across breeds, variation of frame size within breeds, especially for dogs and the veterinarian's and owner's bias for what constitutes a patient's ideal body weight and conformation. For example, most dog and cat owners underestimate their pet's body condition (Singh et al, 2002; Allan et al, 2000). Even veterinarians overlook obesity (Lund et al, 1999). There is no ideal, definitive method for deciding whether a dog or cat is in a thin, ideal, overweight or obese body condition. In reality, a continuum exists from emaciation to morbid obesity, making absolute definitions and divisions arbitrary.

Clinically, it is important to assess body condition of cats and dogs objectively. The ability to assess body condition is necessary to determine when a dog or cat is likely to benefit from weight loss, and to substantiate a diagnosis of obesity for the patient's owners and convince them that their pet needs to lose weight. Radiographic and ultrasound images can be used to help convince an owner his or her pet is overweight (**Box 27-2**); however, these aids do not quantify the degree to which a pet is overweight. Quantifying excess body weight and determining ideal body weight are essential to the effectiveness of a weight-loss program. The most practical method for making these determinations is body condition scoring.

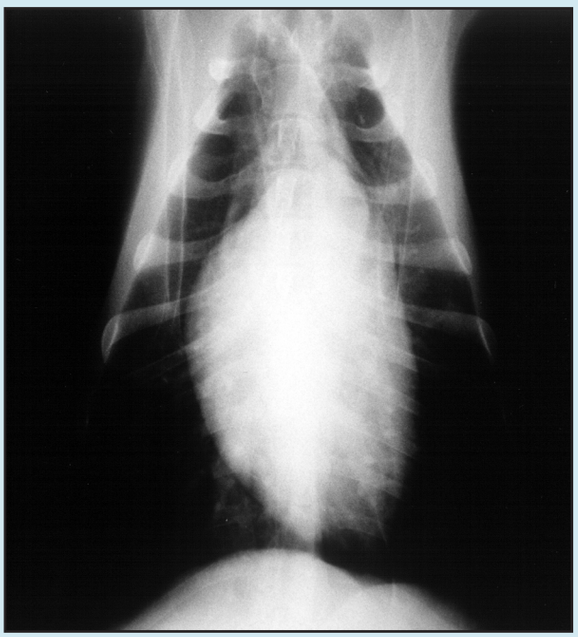
BODY CONDITION SCORING

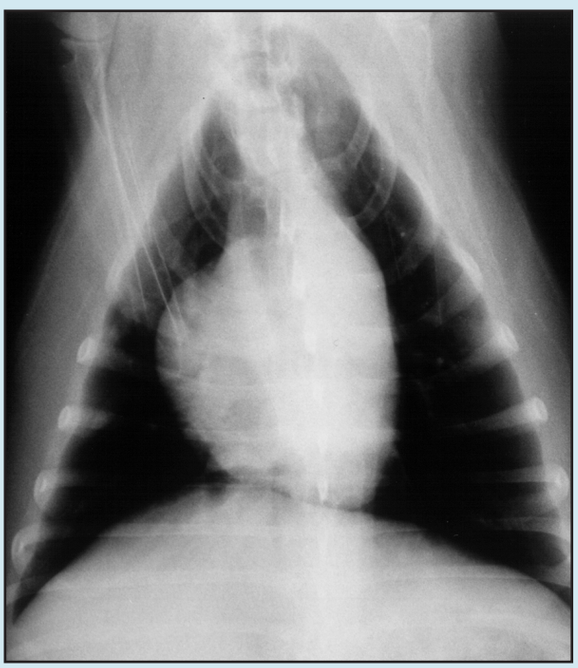
The BCS is a subjective assessment of an animal's body fat, and to lesser extent its protein stores, that takes into account the animal's frame size independent of its weight. Scoring systems using defined criteria help objectify the process, but cannot remove all subjectivity involved in assigning a score to a given patient. Body condition scoring like other physical examination techniques is a learned skill. Within the range of defined criteria, the scorer still must learn by experience what visual and palpable characteristics correspond with a given BCS. Standardization of scores between observers scoring a given animal can be problematic. What one scorer feels to be an excessive amount of fat covering the ribs, another scorer may assess as appropriate. However, once learned, body condition scoring is a reliable indicator for determining the proportion of body fat or body composition (Mawby et al, 2004; Laflamme, 1993, 1997, 1997a; Laflamme et al, 1994; Graham et al, 1982; Croxton and Stollard, 1976).

Different body condition scoring systems for dogs and cats

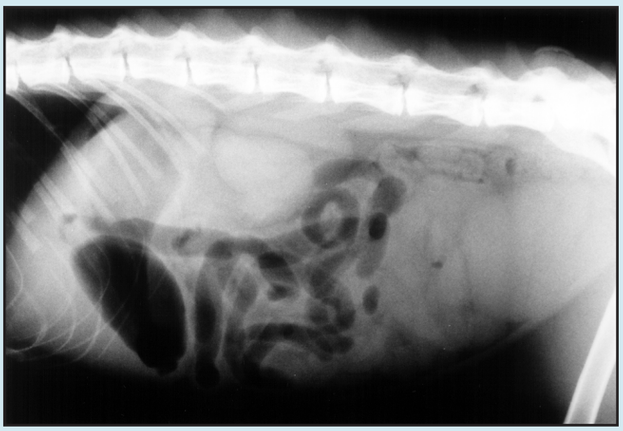
Box 27-2. Other Diagnostic Procedures.

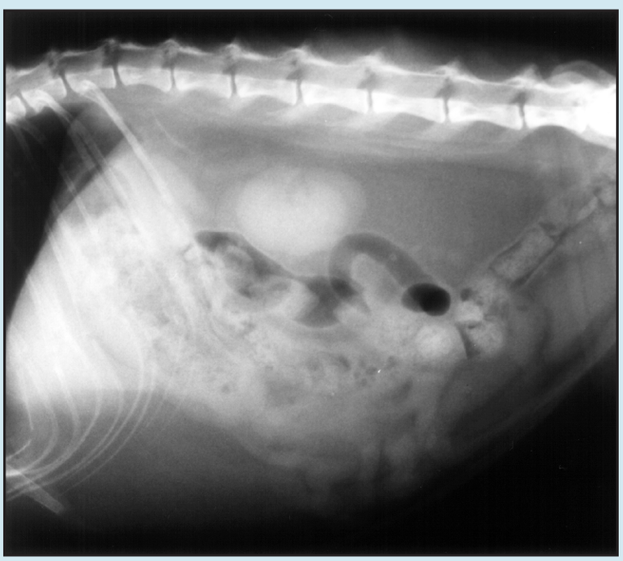
Radiographic or sonographic images can often help an owner appreciate the degree of excess fat deposited subcutaneously or intra-abdominally, particularly when viewed next to radiographs or sonograms of similar size animals that are in optimal body condition (**Figures 1A** and **B** and **2A** and **B**). However, radiographs should not be taken solely for diagnosing obesity. Many veterinary schools now have dual energy x-ray absorptiometry, which can be effectively used for weight-reduction/maintenance programs.





Figures 1A and 1B. Ventrodorsal radiographs of a normal dog (BCS 3/5, above) and an obese dog (BCS 5/5, below). Compare the body wall thickness of the two dogs.





Figures 2A and 2B. Lateral abdominal radiographs of a normal cat (BCS 3/5, above) and an obese cat (BCS 5/5, below). Note the enlarged abdomen and ventral fat deposition in the obese cat.

Table 27-3. Relationships between body condition score (BCS; 5-point system) and actual body weight, ideal body weight, resting energy requirement (RER; kcal metabolizable energy [ME]/day) and estimated percent body fat (%BF). Actual body weight and BCS can be used to estimate a patient's ideal weight* and associated RER, which can be further used for determining the amount of food to feed for weight loss.

BCS						**Body weight (kg)**						
5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5
4	1.7	2.1	2.6	3	3.4	3.9	4.3	4.7	5.1	5.6	6	6.4
3	1.5	1.9	2.3	2.6	3	3.4	3.8	4.1	4.5	4.9	5.3	5.6
RER	95	112	129	144	160	174	189	203	216	230	243	256
BCS						**Body weight (kg)**						
5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5
4	6.9	7.3	7.7	8.1	8.6	9	9.4	9.9	10.3	10.7	11.1	11.6
3	6	6.4	6.8	7.1	7.5	7.9	8.3	8.6	9	9.4	9.8	10.1
RER	268	281	293	305	317	329	341	352	364	375	386	397
BCS						**Body weight (kg)**						
5	14	14.5	15	15.5	16	16.5	17	17.5	18	18.5	19	19.5
4	12	12.4	12.9	13.3	13.7	14.1	14.6	15	15.4	15.9	16.3	16.7
3	10.5	10.9	11.3	11.6	12	12.4	12.8	13.1	13.5	13.9	14.3	14.6
RER	408	419	430	441	451	462	472	483	493	503	513	524
BCS						**Body weight (kg)**						
5	20	21	22	23	24	25	26	27	28	29	30	31
4	17.1	18	18.9	19.7	20.6	21.4	22.3	23.1	24	24.9	25.7	26.6
3	15	15.8	16.5	17.3	18	18.8	19.5	20.3	21	21.8	22.5	23.3
RER	534	553	573	593	612	631	650	668	687	705	723	741
BCS						**Body weight (kg)**						
5	32	33	34	35	36	37	38	39	40	41	42	43
4	27.4	28.3	29.1	30	30.9	31.7	32.6	33.4	34.3	35.1	36	36.9
3	24	24.8	25.5	26.3	27	27.8	28.5	29.3	30	30.8	31.5	32.3
RER	759	777	794	812	829	846	863	880	897	914	931	947
BCS						**Body weight (kg)**						
5	45	47	49	51	53	55	58	61	64	67	70	73
4	38.6	40.3	42	43.7	45.4	47.1	49.7	52.3	54.9	57.4	60	62.6
3	33.8	35.3	36.8	38.3	39.8	41.3	43.5	45.8	48	50.3	52.5	54.8
RER	980	1,013	1,045	1,077	1,108	1,139	1,186	1,231	1,277	1,321	1,365	1,409

BCS	**%BF**	**BCS**	**%BF**	**BCS**	**%BF**
5	**≥40**	**4**	**30**	**3**	**20**

*The formula used to derive the relationship between body weight and BCS is described in **Box 27-3**.

Example: A 32-kg dog has a BCS of 4/5. What is its ideal weight and associated RER and approximate %BF?

1. Find the closest value for its current body weight (31.7 kg) in the row for BCS 4/5.
2. Locate the corresponding body weight for BCS 3/5 (ideal weight) in the same number column. In this case it is 27.8 kg.
3. Below the ideal body weight of 27.8 kg, find the RER value for that weight; in this case it is 846 kcal/day (to convert to kJ, multiply kcal by 4.184).
4. At its current BCS (4/5), the dog's approximate %BF is 30.

contain from three to nine categories for body condition and have been assessed to different extents for precision, accuracy and repeatability (Armstrong and Lund, 1996; Mason, 1970; Edney and Smith, 1986; Scarlett et al, 1994; Joshua, 1970; Laflamme et al, 1994, 1995; Burkholder, 1994; Laflamme, 1993). Chapter 1 presents a 5-point body condition scoring system in detail. Systems with either five or nine categories are used most commonly. A 5-point system scored to the nearest half score and a 9-point system scored to the nearest whole score each have nine total scores for body condition. A 5-point system scored to the nearest half score subdivides into three categories each for insufficient, ideal and excess body conditions, with a score of 3.0 falling in the middle of the optimal range.

In general, dogs and cats in ideal body condition have: 1) normal body contours and silhouettes, 2) bony prominences that can be readily palpated but not seen or felt above skin surfaces and 3) intraabdominal fat insufficient to obscure or interfere with abdominal palpation. The most critical division points in a 5-point system are between the scores of 2.0 vs. 2.5 and 3.5 vs. 4.0, because assignment of a BCS less than 2.5 or greater than 3.5 suggests action should be taken to return the patient's BCS to the optimal range. These same criteria (i.e., what contours are absent that otherwise should be present and what bony prominences should be easily felt but are not readily palpable) can be demonstrated to the patient's owner as part of the educational process to obtain agreement that the patient needs to lose weight.

BCS and body weights should always be recorded in the hospital record whenever a veterinarian or another health-care team member examines a patient. An accurate estimate of the patient's ideal weight is important for a successful weight-loss program. Deciding on an optimal weight can be problematic for the veterinarian and the pet owner, especially if the two disagree. However, after a patient's BCS has been determined, its ideal body weight can be estimated using **Table 27-3**. This is done by locating the patient's body weight for the BCS determined during the physical examination and finding the

patient's corresponding body weight for its ideal BCS (3/5) on the table.

BCS can also be used to estimate %BF because body condition can be defined as the ratio of fat to nonfat tissues (Murray, 1919). If 15 to 20% body fat is accepted as optimal for dogs and cats, then a patient with a BCS of 3 out of 5 (3/5) should have between 15 to 20% body fat. Research to critically assess the capability of BCS to predict body composition suggests that %BF changes by roughly 10% for each change in BCS on a 5-point scale (or 5% on a 9-point scale) (Laflamme et al, 1994; Laflamme, 1997, 1997a). Using the upper end of the range of %BF (20% body fat) for dogs and cats with a BCS of 3/5, a BCS of 4/5 correlates with approximately 30% body fat and a BCS of 5/5 correlates with 40% (or more) body fat (**Table 27-3**). Thirty percent body fat (BCS 4/5) is similar to the critical %BF for assessing when people are at risk for ill effects from being overweight. Most studies critically assessing the precision of BCS against some criterion measure of body fat indicate that %BF is estimated with a standard deviation of ± 4 to 5% (Laflamme et al, 1994; Burkholder, 1994; Laflamme, 1993; Graham et al, 1982; Croxton and Stollard, 1976).

One misconception that could arise about body condition scoring is the implication that some maximum amount of body fat corresponds to the maximum BCS. BCS have a maximum upper number assigned to the fattest animals used to define the scoring criteria, which consequently is associated with the mean %BF of those animals. However, the maximum amount of body fat compatible with life is unknown and is very likely more than the approximate value of 40% body fat of all dogs or cats with a BCS of 5/5. The correct interpretation for %BF based on assigning a maximum BCS should be that the animal has at least 40% body fat, but the %BF could be considerably higher. **Box 27-3** reviews obesity classification in people and proposes a similar method be considered for obese dogs and cats.

OTHER METHODS

Although not as practical as BCS, other means exist to determine whether a dog or cat is at optimal weight, overweight or obese. These include ultrasound, morphometric analysis and methods that are currently too expensive or otherwise impractical for use in private practice.

Ultrasound has been used to estimate back fat thickness in livestock including swine, cattle, sheep, horses and ponies. Ultrasound has also been used in people to determine %BF (Stouffer, 2004). Because ultrasound is routinely used as a diagnostic tool in small animal medicine, it has potential for determining %BF in dogs and cats. In combination with specific morphometry, it predicts %BF in beagles (Yamka et al, 2007).

%BF can also be estimated with morphometry (i.e., measurement of form). Morphometric analyses are routinely used in people to estimate body composition and %BF from measurements of various anatomic circumferences and lengths (Houmard et al, 1991; Weltman et al, 1987, 1988; Davis et al, 1985). The success for measurements made in specific locations to estimate overall body composition depends on correlation of measurements to total body composition. In people, BMI is practical because of the small range of body types. Even in people, the accuracy of BMI is influenced by differences in bone size. However, because of the immense diversity of body types within the canine species (e.g., English bulldog vs. greyhound), the use of morphometric analysis to estimate body fat requires more measurements and complex math to provide reasonable estimates of body fat than it does in people. Furthermore, fat is deposited in slightly different body sites in cats compared to dogs. Cats store most of their fat subcutaneously along their ventral abdomen, in their faces and intra-abdominally. Dogs deposit significant amounts of fat intra-abdominally and subcutaneously in thoracic, lumbar and coccygeal areas.

Methods for morphometric analysis of dogs and cats have been determined (Laflamme et al, 2001; Burkholder, 1994; Stanton et al, 1992). Besides the shortcomings mentioned above of using this technology in dogs and cats, repeatability is a concern. Differences in measurements occur due to: 1) variations in coat thickness, 2) operator variability (i.e., tension on the tape measure), 3) operator variability in determining the precise location of anatomic landmarks for measurement and 4) patient restraint, particularly in cats. Cats usually require anesthesia to obtain accurate measurements (Burkholder and Toll, 2000).

Weight at the time the dog or cat reaches adult age is often a good indicator of optimal weight if body condition assessments are unavailable. However, weight at maturity may not automatically be optimal if the animal was underfed or overfed during growth. For most dogs and cats, maturity occurs around 12 months of age. Giant-breed dogs, however, may require up to 18 months to reach mature adult weight.

For purebred dogs, determining optimal weight from published optimal weights by breed is often not accurate enough for an individual within a breed. A similar approach has been considered for cats based on body type and the fact that cats have less variability of body weights than dogs (Burkholder and Toll, 2000). Neither method is accurate enough to be used routinely as the basis for an effective weight-reduction feeding plan. Appendices 14 and 15 list proposed optimal weights for dog breeds by gender based on data from the American Kennel Club and other sources.

There are multiple methods that vary widely in cost, sophistication and precision for estimating %BF in people (Brodie, 1988, 1988a; Lukaski, 1987). Some are used for determining %BF in dogs and cats in research settings. Several methods are available for determining body composition, and thus, %BF: 1) magnetic resonance imaging, 2) computed tomography, 3) neutron activation, 4) hydrodensitometry, 5) total body water by isotope dilution, 6) total body potassium, 7) ultrasound, 8) bioelectrical impedance and 9) dual energy x-ray absorptiometry (Brodie, 1988, 1988a; Lukaski, 1987). Unfortunately, at this time, most of these methods are impractical for use in private veterinary hospitals.

Box 27-3. Proposed Refinement of Body Condition Score (BCS) Classification of Obese Dogs and Cats (BCS 5/5).

In people, body mass index (BMI) is a very useful tool for classifying the degree of overweight and obesity. Furthermore, BMI is related to the risk for the development of diseases associated with obesity, because BMI, which describes relative weight for height, is significantly correlated with body fat content. BMI is calculated by dividing body weight (kg) by height squared (m^2). The resultant BMI value is not the same as percent body fat. In people, **Table 1** is used for classification of overweight and obesity, by BMI.

The rationale behind these definitions is based on epidemiologic data that show increased mortality with BMIs greater than 25. The increase in mortality, however, tends to be modest until a BMI of 30 is reached. For persons with a BMI greater than 30, mortality rates from all causes, but especially from cardiovascular disease, are generally increased by 50 to 100% above that of people with BMIs in the range of 20 to 25. For people with BMIs greater than 35 (obesity II) and 40 (extreme obesity), mortality rates are further increased.

BMI has not been determined for dogs and cats. Morphometric measures established for companion animals are similar but much more complicated to obtain and therefore, less reliable.

Assessing BCS combined with data from **Table 27-3** (See text.) is a simple and reliable method for determining the degree of overweight and obesity in dogs and cats. However, after a patient reaches a BCS of 5, there is potential for considerable variability regarding how obese the patient could be. Thus, as for obesity classifications in people using BMI, the BCS 5/5 (>40% body fat) could be further categorized to indicate degrees of obesity in cats and dogs. **Table 2** presents such a proposed classification.

The added dimension of BCS 5/5 subcategories 5 (a,b,c) would better define the degree of obesity and could be used to improve the estimation of ideal weight in very obese and extremely obese patients, which could lead to a more appropriate amount of food to feed these patients for weight loss.

The discrepancy in food dosage that can result from whether a patient with a BCS of 5/5 has 40% body fat or 60% body fat is significant. For example, if a patient has 40% body fat and a current (obese) weight of 30 kg, its estimated ideal (target) weight would be 22.5 kg and its estimated resting energy requirement (RER) would be 745 kcal/day. However, a 30-kg patient with 60% body fat would have an ideal weight of 15 kg and its RER would be 520 kcal/day; a considerable difference of 225 kcal/day (**Table 27-3** and **Table 3**).

However, currently there are no descriptive and/or visual standards for subdividing the obese category of either the 5-point or 9-point systems. Until such tools are developed, the initial phases of weight-loss programs should be closely monitored and further restrictions of caloric intake should be instituted if weight loss does not occur within two weeks (**Figure 27-1**). Underestimation of percent body fat and resultant overestimation of ideal weight can be problematic when designing weight-loss programs for extremely obese patients.

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Table 1. Human overweight and obesity classifications.

Class	Obese class	BMI (kg/m^2)
Underweight	-	<18.5
Normal	-	18.5 to 24.9
Overweight	-	25.0 to 29.9
Obesity	I	30.0 to 34.9
	II	35.0 to 39.9
Extreme obesity	III	≥40

Table 2. Proposed classification scheme for BCS and degrees of obesity in companion animals.

Class	BCS	Body fat (%)
Very thin	1	<5
Underweight	2	10
Normal	3	20
Overweight	4	30
Obese	5(a)	40
Very obese	5(b)	50
Extremely obese	5(c)	≥60

Table 3. The ideal weight formula used to develop the body weights in **Table 27-3** and in the examples above.

Ideal weight = current weight x (100 - percent body fat [%BF]) ÷ 0.80

The assumptions and definitions used to derive this formula include:

a) Current weight (overweight due to excess adipose tissue); obtain by weighing patient
b) Body weight = fat mass + lean body mass (LBM)
c) LBM is constant between ideal and current weights
d) %BF can be estimated from BCS
e) Ideal %BF = 20%; thus, ideal LBM = 80%
f) %LBM = 100 - %BF
g) Ideal weight = LBM ÷ 0.80
h) LBM = current weight x %LBM

The steps for deriving the formula include:
Ideal weight = current weight (100 - %BF) ÷ 0.80

a) If ideal weight = LBM (g)* ÷ 0.80
b) And if LBM = current weight x %LBM (h)*
c) Then, ideal weight also = current weight x %LBM ÷ 0.80
d) And if %LBM also = 100 - %BF (f)*
e) Then ideal weight also = current weight (100 - %BF) ÷ 0.80

*Letters refer to the assumptions and definitions immediately above.

The Bibliography for **Box 27-3** can be found at www.markmorris.org.

Etiopathogenesis and Risk Factors

Energy Balance and Body Composition Control

Positive energy balance results when consumption of calories exceeds daily energy expenditure. This may result from energy intake increases and/or energy expenditure decreases. When positive imbalance is sustained, excess energy is stored in adipose tissue and overweight or obese body conditions develop due to excess body fat. An understanding of the components that contribute to the energy input side of the equation (i.e., the daily energy requirement [DER]), explains why animals of similar body weight and frame size can have different caloric requirements independent of genetics or neuter status. Understanding DER components simplifies the rationale behind recommendations and alterations made to correct obesity. Multiple components contribute to DER. The DER to maintain body weight of an animal can be subdivided into: 1) resting energy requirement (RER), 2) exercise energy requirement (EER), 3) thermic effect of food (TEF) and 4) adaptive thermogenesis (AT). In people, RER correlates closely with lean body mass and accounts for 60 to 80% of the total DER for adult maintenance (Danforth, 1985; Horton, 1983; Wilson, 1990). RER represents energy used to maintain normal physiologic functions at rest in a thermoneutral environment several hours after eating (Horton, 1983). Very little energy is required to maintain adipose tissue.

EER is the energy expended for muscular activity. The contribution of EER to DER is determined by the animal's body weight plus the duration and intensity of muscular activity. Animals that are less active or have little opportunity to exercise expend less energy compared with active animals of similar size. EER can account for 10 to 20% of total daily energy expended by nonathletic people (Danforth, 1985).

TEF represents the obligatory cost of digesting and absorbing food. TEF constitutes approximately 10% of total expenditure and is affected by food composition and the number of meals eaten per day (Danforth, 1985; Horton, 1983). The obligatory cost associated with digesting and absorbing each meal is the reason weight-reduction programs recommend multiple small meals per day rather than one or two large meals. RER, EER and TEF make up the majority of DER; thus, these are the components that can be manipulated to affect the amount and rate of weight loss.

AT makes up the smallest proportion of the DER for most pets. AT is the energy expended to regulate body temperature during exposure to ambient temperatures below or above the thermoneutral zone or during transient periods of excess caloric consumption.

Most dogs and cats maintain an ideal, constant body weight due to a complex system of neural, hormonal and biochemical mechanisms that keep the balance between energy intake and expenditure within fairly precise limits (**Boxes 27-4** and 25-2) (Druce and Bloom, 2003). Thus, under normal circumstances, homeostatic mechanisms control energy intake and maintain body composition at or near some "set point." Set point can be defined as the physiologic regulation of energy balance that maintains stable body condition. When certain abnormal conditions are imposed on these set point mechanisms, positive energy balance occurs and excess body fat accumulates. Several of these risk factors are discussed below.

Box 27-4. Central Regulators of Food Intake and Energy Balance.

Numerous feedback mechanisms exist to control eating and energy stores (Box 25-2). These mechanisms are designed to store energy as fat when energy sources are plentiful so animals can survive when food is not readily available (famine or hibernation). Three regulators of food intake and energy balance that have received attention recently include neuropeptide Y (NPY), leptin and ghrelin.

NPY is a hypothalamic hormone; its synthesis increases when an animal is deprived of food. Repeated injections of NPY into the brain results in consumption of larger meals, weight gain and obesity.

Leptin is a polypeptide hormone synthesized by white adipose tissue and secreted into the bloodstream. Leptin regulates energy intake, energy expenditure and acts at the hypothalamus to reduce synthesis of NPY, thereby down regulating food intake. Leptin secretion is proportional to the amount of lipid stored in adipocytes. As a result, serum leptin concentrations are highly correlated with obesity in rodents, dogs, cats and people.

The obese gene ("ob gene") codes for leptin and is absent in one strain of genetically obese mice ("ob mice"), thus this mouse strain readily becomes obese. Long-term treatment of ob mice with exogenous leptin causes a decline in eating and is associated with loss of body weight. In dogs, leptin injections resulted in decreased food intake and body weight. The reduction in body weight and food intake in both species is believed to be an attempt by the animal to limit weight gain.

Ghrelin is a gastric peptide and a secretagogue of growth hormone. Ghrelin controls feeding behavior, energy homeostasis, gastric acid secretion and gastric motor activity and is essential for growth hormone release. Ghrelin levels increase during fasting and decline shortly after eating. In obese dogs and cats, ghrelin and leptin levels are inversely related. The lower ghrelin levels observed in obese animals likely result from down regulation of this peptide due to excess energy storage.

The Bibliography for **Box 27-4** can be found at www.markmorris.org.

Risk Factors

Several risk factors contribute to positive energy balance and affect the body's compositional set point. They can be grouped under the headings of genetic and environmental. Although genetic risk factors make it easier for positive energy balance and obesity to develop, environmental risk factors dictate the expression of that potential and, thus, the overweight/obesity condition. Although the greater opportunity for intervention is in managing environmental risk factors, the opportunity for prevention includes management of both. Prevention of obesity is critical (Chapters 13 through 17 and

Box 27-5. Lipoprotein Lipase and Obesity Recurrence.

Following weight loss of an obese patient, weight regain is likely if there is not strict adherence to appropriate diet and exercise programs. This may be due in part to the change in lipoprotein lipase (LPL) activity.

After digestion and absorption, dietary fat is transported to adipose tissue via chylomicrons. LPL is an enzyme located in the capillaries of body fat and facilitates removal of dietary fat (triglycerides) from the chylomicrons in the bloodstream and its entry through capillary walls into adipocytes. LPL hydrolyzes triglycerides into free fatty acids and glycerol. Fatty acids enter adipocytes, where they are re-esterified into triglycerides and stored. When needed by other body cells for energy, stored triglycerides are hydrolyzed once again to fatty acids and glycerol by hormone sensitive lipase (HSL) and reenter the circulation.

LPL increases during periods of weight gain in both obese and non-obese people. After weight is lost, LPL returns to normal levels in non-obese people; however, in obese patients that have lost weight, LPL increases. This increase is probably one of the factors contributing to the rapid weight regain that is common in obese human patients and could also be a culprit in weight regain in previously overweight dogs and cats.

The Bibliography for **Box 27-5** can be found at www.markmorris.org.

20 through 24); weight loss is more difficult after body fat is gained and maintained (Laquatra, 2000) (**Box 27-5**). Under these conditions, the body essentially has a new set point. All risk factors should be understood if obesity is to be prevented and treated effectively.

Genetics

Obesity in people has a large propensity for being heritable, accounting for 37 to 40% of BMI (Coady et al, 2002). Genetics likely determine the concentration and activity of various metabolic regulators, their receptors and, thus, metabolic efficiency (Bogardus et al, 1986; Campfield et al, 1995; Halaas et al, 1995; Pelleymounter et al, 1995). Various genetic factors also influence the risk of obesity in dogs; breed accounts for 30 to 70% of the risk (Buffington et al, 2004). Some breeds are more likely to be overweight. Breed prevalence within a geographic area influences the prevalence of obesity in specific breeds. Labrador retrievers, golden retrievers, Cairn terriers, cocker spaniels, long-haired dachshunds, Shetland sheepdogs, basset hounds, cavalier King Charles spaniels, pugs, Dalmatian dogs and beagles have a greater prevalence of obesity than other breeds (Mason, 1970; Edney and Smith, 1986; Lund, 2007). In contrast to dogs, cats of mixed breeding are more likely to be obese than purebred cats (Scarlett et al, 1994). These findings suggest that genetics influence body condition set points and the tendency for weight gain or loss in dogs and cats.

Certain genes appear to be related to obesity. Compared to lean beagles (BCS 2.2/5), overweight beagles (BCS 4.3/5) had higher expression of genes associated with fatty acid metabolism, purine metabolism and platelet-derived growth factor signaling. In addition, the overweight beagles had lower expression of genes associated with nucleotide metabolism, carbohydrate metabolism, peroxisome proliferator-activated receptor signaling, insulin-like growth factor-1 signaling, insulin receptor signaling, amino acid metabolism, branched-chain amino acid degradation and lipid metabolism (Yamka et al, 2007a).

Food and Feeding

Specific attributes of foods and how foods are fed can overwhelm normal body condition set point systems and result in positive energy balance. Such food attributes include palatability and energy density. Feeding methods that further aggravate food attributes include how much is fed and how it is offered (e.g., free-choice feeding of highly palatable, energy-dense foods).

Food palatability is a highly competitive attribute in the pet food industry. Feeding pets and watching them eagerly eat is part of the pleasure people derive from having pets and apparently contributes to the human-animal bond. Palatability is also an attribute that owners perceive reflects a food's quality. Thus, pet food companies continuously strive to improve the palatability of their food, because having a highly palatable food is a competitive advantage. If the amount of a highly palatable food isn't limited, it stands to reason that a pet is more likely to overeat. Normal body condition set point systems may not have been designed to deal with some of the highly palatable foods that exist today.

Caloric density of a food is primarily a function of its dietary fat content. On a weight basis, in typical commercial pet foods, dietary fat provides 8.5 kcal (35.6 kJ) metabolizable energy (ME)/g compared to 3.5 kcal (14.6 kJ) ME/g for carbohydrate and protein. Most of the lipid in fat cells comes directly from dietary fat. In general, the fatty acid composition of body fat mirrors the fatty acid composition of the food (Laquatra, 2000). Conversely, inclusion of dietary fiber, water or air can decrease caloric density by taking up space in the food while providing few to no calories.

One study found no difference in types of food given to overweight pets compared with foods given to those in optimal body condition (Edney and Smith, 1986). Other studies demonstrated an increased risk for being overweight when certain food categories were fed (Mason, 1970; Scarlett et al, 1994). In these studies, all of the associated foods, whether commercial or home prepared, were considered calorically dense, although caloric density per se was not the variable tested for increased risk of being overweight.

Free-choice feeding can also contribute to excessive caloric intake. Feeding unlimited amounts of highly palatable, energy-dense foods to dogs and cats may encourage energy consumption that exceeds requirements, particularly if a genetic predisposition exists. Likewise, excessive use of treats or substitution of food (and treats) for other types of interaction between the owner and pet may also encourage excess energy intake.

Determining amounts to feed based on manufacturer recom-

mendations may also lead to excessive caloric intake. This results not because manufacturers make inappropriate or self-serving recommendations, but rather because manufacturers base recommendations on ranges and average caloric requirements for a given body weight. Recommendations often list a minimum and maximum amount of food to feed within a given range of body weights (e.g., two to four cups for a 5.9- to 11.4-kg dog). The maximum amount can be one and one-half to four times the minimum amount listed for a given range of body weights. Excess caloric intake can occur if pet owners interpret that a smaller dog should be fed the larger amount. Furthermore, excess caloric intake can occur because pet owners overestimate the activity of their pet. Many pets today are relatively inactive due to the lifestyle of their owners. (See Activity below.) Also, cat and dog owners underestimate the body condition of their pets (Singh et al, 2002; Allan et al, 2000), increasing the likelihood that pets will be overfed.

Activity

Many pets, particularly cats, live indoors, which is often associated with reduced physical activity. Physical activity is the most variable component of energy expenditure. Adequate exercise can contribute markedly to daily energy expenditure. Furthermore, the risk of obesity decreases with each hour of weekly exercise in dogs (Robertson, 2003). Thus, it is not surprising that animals with decreased activity or restricted opportunities for exercise are at greater risk for becoming overweight (Scarlett et al, 1994). Unfortunately, most owners consider their dogs to be moderately or very active (Slater et al, 1995).

Caloric intake can also become excessive if changes occur in a pet's lifestyle or daily routine that markedly reduce activity without reducing calories. Such changes include moving to smaller dwellings, musculoskeletal injuries and diseases that require persistent long-term use of central nervous system depressants or corticosteroids.

Age

Caloric requirements decrease as some animals age. Requirements for a given weight are less for maintenance of adults than for growing individuals of similar weight. Age has been correlated with the prevalence of excess body weight in dogs and cats (Armstrong and Lund, 1996; Mason, 1970; Scarlett et al, 1994; Sloth, 1992; Kronfeld et al, 1991). Dogs and cats have the highest prevalence of obesity from five to 11 years of age (Lund et al, 2005, 2006). After about 12 years of age, the prevalence tends to decrease markedly in most cross-sectional studies (Armstrong and Lund, 1996; Scarlett et al, 1994; Sloth, 1992; Kronfeld et al, 1991). These observations have bearing on two theories concerning obesity and aging. First, one theory suggests that aging causes a decrease in energy requirement as a result of concomitant loss of lean body tissue and that obesity will result if energy intake fails to decrease. Except for one study (Mason, 1970), the data from other cross-sectional studies appear not to support this theory on initial examination (Armstrong and Lund, 1996; Scarlett et al, 1994; Sloth, 1992; Kronfeld et al, 1991). Instead, dogs and cats 12 years of age or older become thinner and tend to be in less than optimal body condition (Armstrong and Lund, 1996; Scarlett et al, 1994; Kronfeld et al, 1991).

However, an alternate hypothesis suggests that overweight dogs and cats die sooner and do not reach ages attained by thinner animals because excess weight is detrimental to overall health (Armstrong and Lund, 1996). Caloric consumption has been inversely related to lifespan of dogs (Kealy et al, 2002), rodents (Masoro, 1984, 1988, 1992) and rhesus monkeys (Lane et al, 1997). Cats may be similarly affected.

Gender and Neuter Status

Small differences in body composition and energy intake between intact male and intact female cats have been reported (NRC, 1986; Jewell et al, 1996). The differences in energy intake appear to be due to gender-related differences in lean body mass (Jewell et al, 1996; Klausen et al, 1997).

No controlled studies have been done in dogs to measure differences between energy requirements of intact males compared to intact females. As in other mammals (e.g., cats) intact females probably require less caloric intake than intact males. This assumption is probably due to gender-related differences in lean body mass. The lean body mass of an animal accounts for nearly all of its RER (Blaxter, 1989).

One study showed that female dogs had an average of 16% more body fat than male dogs (Meyer and Stadtfeld, 1980). These findings suggest that intact female dogs need fewer calories than intact male dogs. Surveys found a much higher prevalence of overweight and obese female than male dogs (Edney and Smith, 1986; Mason, 1970).

Neutering increases the risk of obesity in dogs and cats (Jeusette et al, 2006; Lund et al, 2005; McGreevy et al, 2005; Kanchuk et al, 2003; Scott et al, 2002; Martin et al, 2001; Harper et al, 2001; Robertson, 1999; Fettman et al, 1997; Root et al, 1996). Neutered cats are more likely to be overweight than are intact cats of either gender (Scarlett et al, 1994; Root and Johnston, 1995; Flynn et al, 1996). Neutered female dogs are about twice as likely to be overweight than are intact female dogs (Edney and Smith, 1986). A similar trend occurs in castrated male dogs (Edney and Smith, 1986). Neutering predisposes dogs and cats to weight gain and eventual obesity for several reasons. Neutered cats had resting metabolic rates 20 to 25% below those of intact cats of similar age, as measured by indirect calorimetry (Root et al, 1996). In practical terms, this finding indicates that neutered cats require only 75 to 80% of the food needed by intact cats to maintain optimal body weight. These studies confirm the previously suspected decrease in metabolic rate caused by loss of estrogens and androgens from neutering. This reduction in resting metabolic rate appears to be in addition to any decrease in physical activity that might occur from decreased roaming and sexual behavior (Hart and Barrett, 1973; Hopkins et al, 1976).

Furthermore, estrogens suppress appetite in several animal species (Czaja and Goy, 1975). Neutered female beagles and cats will eat more food and gain more weight than sham-operated females fed an identical food (Flynn et al, 1996; Houpt et

Table 27-4. Key nutritional factors for calorie-restricted dog foods for weight loss and prevention of weight regain.

Factors	Dietary recommendations (dry matter basis)
Energy density	Foods for weight loss and prevention of weight regain should contain ≤3.4 kcal (≤14.2 kJ) metabolizable energy (ME)/g
Fat	Foods for weight loss should contain ≤9% Foods for prevention of weight regain should contain ≤14%
Fiber	Foods for weight loss should contain 12 to 25% Foods for prevention of weight regain should contain 10 to 20%
Protein	Foods for weight loss should contain ≥25% Foods for prevention of weight regain should contain ≥18%
Lysine	Foods for weight loss should contain ≥1.7%
Carbohydrate	Foods for weight loss should contain ≤40% Foods for prevention of weight regain should contain ≤55%
L-carnitine	Foods for weight loss and prevention of weight regain should contain ≥300 ppm
Antioxidants	Foods for weight loss and prevention of weight regain should contain:
Vitamin E	≥400 IU vitamin E/kg
Vitamin C	≥100 mg vitamin C/kg
Selenium	0.5 to 1.3 mg selenium/kg
Sodium	Foods for weight loss and prevention of weight regain should contain between 0.2 to 0.4%
Phosphorus	Foods for weight loss and prevention of weight regain should contain between 0.4 to 0.8%

Table 27-5. Key nutritional factors for calorie-restricted cat foods for weight loss and prevention of weight regain.

Factors	Dietary recommendations (dry matter basis)
Energy density	Foods for weight loss should contain ≤3.4 kcal (≤14.2 kJ) metabolizable energy (ME)/g Foods for prevention of weight regain should contain ≤3.8 kcal (≤15.9 kJ) ME/g
Fat	Foods for weight loss should contain ≤10% Foods for prevention of weight regain should contain ≤18%
Fiber	Foods for weight loss should contain 15 to 20% Foods for prevention of weight regain should contain between 6 to 15%
Protein	Foods for weight loss and prevention of weight regain should contain ≥35%
Carbohydrate	Foods for weight loss should contain ≤35% Foods for prevention of weight regain should contain ≤40%
L-carnitine	Foods for weight loss and prevention of weight regain should contain ≥500 ppm
Antioxidants	Foods for weight loss and prevention of weight regain should contain:
Vitamin E	≥500 IU vitamin E/kg
Vitamin C	100 to 200 mg vitamin C/kg
Selenium	0.5 to 1.3 mg selenium/kg
Sodium	Foods for weight loss and prevention of weight regain should contain between 0.2 to 0.6%
Phosphorus	Foods for weight loss and prevention of weight regain should contain between 0.5 to 0.8%

al, 1979). Thus, removal of the metabolic effects of estrogens and androgens by gonadectomy may lead to increased food consumption, when at the same time the animal's energy requirement is lower because of its decreased metabolic rate and physical activity.

Thus, prudent postneutering feeding recommendations for young adult dogs and cats include: 1) feeding low-calorie foods or restricted feeding of regular foods (three-fourths of previous amount) and 2) obtaining body weight and BCS every two weeks for four or five months after neutering to ensure maintenance of normal body weight and condition.

Viral Infections

To date, eight viruses have been shown to cause obesity in animals (Atkinson, 2008). Several viruses cause obesity in laboratory animals (Dhurandhar, 2001). Canine distemper virus can disrupt hypothalamic function and down regulation of genes for melanin production, causing obesity (Verlaeten et al, 2001). Adenoviruses have been associated with viral-induced obesity in people, monkeys, chickens, mice and rats (Atkinson, 2007).

Key Nutritional Factors: Calorie-Controlled Foods for Weight Loss and Prevention of Weight Regain in Dogs and Cats

The traditional method to achieve weight loss in overweight pets and to prevent regain of lost weight is to feed calorie-restricted foods. Such foods should provide amounts of the key nutritional factors listed in **Tables 27-4** (dogs) and **27-5** (cats). Key nutritional factors are described in more detail below.

Energy Density

Decreasing the daily caloric intake of overweight dogs and cats is the primary strategy for producing weight loss and subsequently maintaining reduced body weight. Most typical maintenance-type pet foods are nutritionally balanced according to their energy density and the expected intake required to support a given body weight. If energy restriction is attempted by simply reducing the amount of the maintenance food currently being fed, the intake of all nutrients is restricted, not just energy. A deficiency in energy and other nutrients can occur if the amount of a maintenance food being fed is markedly decreased to produce weight loss.

A better approach is to use an energy-restricted food. A properly formulated restricted-calorie food will be replete in all nutrients except energy so that protein, essential fatty acids, vitamins and minerals are present in amounts sufficient to support normal physiologic processes and retention of lean body tissue, even when calorie intake is insufficient to maintain body weight. The goal of a weight-management food should be to restrict only energy, not other nutrients.

Thus, foods sufficiently restricted in energy content are more suitable for weight management. Pet foods marketed as restricted in calories can vary widely in caloric content, including the proportion of nutrients contributing calories, fiber and digestibility. Regulatory definitions for the terms "light," "lean," "reduced calorie" and "reduced fat" have been implemented in the United States (**Box 27-6**).

For optimal performance, the energy content of dog foods for weight loss and prevention of weight regain should be no

Box 27-6. Regulatory Definitions for Descriptive Terms Indicating Restricted Calories or Fat.

Model Pet Food Regulation PF10 of the Association of American Feed Control Officials (AAFCO) defines limits and labeling requirements for claims related to restricted calorie and fat content. The regulation was implemented in the United States in January 1998.

Maximum calories or fat allowed for "light" or "lean" claims depending on moisture content and intended species*

	Dry foods (<20% moisture)	**Semi-moist foods** (20 to <65% moisture)	**Moist foods** (≥65% moisture)
		Dogs	
Light (also "lite," "low calorie")	3,100 kcal ME/kg as fed	2,500 kcal ME/kg as fed	900 kcal ME/kg as fed
Lean (also "low fat")	9% fat as fed	7% fat as fed	4% fat as fed
		Cats	
Light (also "lite," "low calorie")	3,250 kcal ME/kg as fed	2,650 kcal ME/kg as fed	950 kcal ME/kg as fed
Lean (also "low fat")	10% fat as fed	8% fat as fed	5% fat as fed

Key: ME = metabolizable energy.
*"Light" (or similar terms) on pet food labels must bear a calorie content statement as described in AAFCO PF9. "Lean" and "low fat" pet food labels must bear a maximum percentage crude fat guarantee.

"Less" or "Reduced Calories"
For dog or cat food labels bearing a claim of "less calories," "reduced calories" or similar words, a maximum level of calories is not stipulated in the regulations. However, the percentage of reduction and the product of comparison must be explicitly stated on the label. The product label must also bear a calorie content statement and feeding directions should reflect a reduction in calories compared with feeding directions for the product of comparison. Comparisons between products in different categories of moisture content are considered misleading.

"Less" or "Reduced Fat"
For dog or cat food labels bearing the claims of "less fat," "reduced fat" or similar words, a maximum percentage of fat is not stipulated in the regulations. However, the percentage of reduction and the product of comparison must be explicitly stated on the label. The product label must also bear a maximum crude fat guarantee immediately after the minimum crude fat guarantee in the mandatory guaranteed analysis information. Comparisons between products in different categories of moisture content are considered misleading.

The Bibliography for **Box 27-6** can be found at www.markmorris.org.

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more than 3.4 kcal (14.2 kJ) metabolizable energy (ME)/g on a dry matter (DM) basis.

For energy-restricted foods for weight loss in cats, the energy density should be no more than 3.4 kcal (14.2 kJ) ME/g DM. For prevention of weight regain in cats following weight reduction, the energy density of the food should be no more than 3.8 kcal (15.9 kJ) ME/g DM. Pet food manufacturers decrease the energy density of foods by reducing fat and simultaneously increasing the fiber, air or moisture content of the food.

Fat

Most typical maintenance-type pet foods contain more fat than do energy-restricted foods. Fat has about 2.25 times the calories of an equivalent weight of carbohydrate or protein. In addition, fat is a very efficiently digested and metabolized source of energy. In one study, overweight dogs fed restricted calories from a food containing more fat lost less body weight and body fat than did overweight dogs fed equivalent calories from a food containing less fat (Borne et al, 1996). The thermal effect of dietary fat is less than the TEF of dietary carbohydrate or protein in obese people (Swaminathan et al, 1985). Studies in people have also determined that the lipid in body fat stores comes primarily from dietary fat, whereas an increased TEF is more closely correlated with carbohydrate intake (Danforth, 1985). Thus, a food with more calories supplied from fat will tend to support retention of body weight and body fat even when total calories consumed are reduced.

The recommended upper limit for dietary fat for weight loss in dogs is 9%, DM; for preventing regain of weight, the upper limit is 14% DM fat. The recommended upper limit for dietary fat for weight loss in cats is 10%, DM; foods for preventing weight regain should contain no more than 18% DM fat.

Fiber, Water and Air

There is some debate regarding the use of calorie-diluting agents in foods intended for weight management. Typical calorie-diluting agents are dietary fiber, water and air. Air is sometimes used to reduce caloric density in dry foods only. Water is a factor in moist foods. Water and air are removed from the gastrointestinal (GI) tract and contribute only transiently to GI fill. However, dietary fiber, besides diluting calories (Laflamme and Jackson, 1995; Jackson et al, 1997; Fekete et al, 2001), offers several physiologic and nutritional effects.

Dietary fiber helps produce weight loss by diluting calories, increasing satiety and limiting food consumption as a result of more bulk being present during its transit through the GI tract (Levine and Billington, 1994). Fiber may also help produce weight loss by decreasing the availability of calories by interfering with the digestion and absorption of fat, protein and digestible carbohydrate (Levine and Billington, 1994). Many of the effects of dietary fiber depend on the specific type, form and amount of fiber used.

Increased levels of dietary fiber contribute to satiety via prolonged distention of the GI tract. Fiber types affect the duration of gastric and intestinal distention differently. Insoluble fibers have little effect on gastric emptying, whereas soluble fibers slow gastric emptying (Levine and Billington, 1994; Vahouny, 1987; de Haan et al, 1990). Although both soluble and insoluble fibers slow intestinal transit, insoluble fiber (e.g., purified cellulose) produces the greater effect (Bueno et al, 1981). Thus, even though the type of fiber affects the two segments of the GI tract differently, total transit time through the entire GI tract is increased and is approximately the same for soluble and insoluble fibers.

Besides affecting transit time, mixed fibers are thought to promote weight loss through delayed gastric emptying, increased ileal transit time and increased gastric distention. Gastric distention stimulates cholecystokinin secretion, thus affecting appetite. However, the ratio of slowly to rapidly fermentable fibers is important (Kritchevsky, 2001). Dog foods with mixed fiber sources provide good weight loss performance (Yamka et al, 2007b).

Actual documentation of increased satiety from dietary fiber is difficult to prove in people and more so in other animals, because satiety is a subjective feeling of fullness and a lack of desire to eat. Indirect evidence for satiety can be obtained from animals by measuring decreases in food consumption and food-seeking activities. In people, increased intake of dietary fiber decreases food intake for variable periods lasting up to eight hours (Burley et al, 1987; Delargy et al, 1993; Stevens et al, 1987). Studies in dogs have produced variable results. Some studies in dogs showed no effect on caloric intake when foods containing 12 to 14% of DM as soluble or insoluble fibers were fed (Fahey et al, 1990, 1990a). In one study, foods containing either 2.2 or 15.6% fiber did not produce any measurable difference in satiety (Butterwick et al, 1994). However, the dogs in this study were fed quantities of food supplying only 40% of calories for adult maintenance, and this degree of caloric restriction may have overshadowed any effect of fiber between the two groups. In another study, dogs offered maintenance calories from food containing 21% insoluble fiber consumed significantly less food and calories than when offered equivalent calories from foods containing less fiber (Jewell and Toll, 1996). These dogs also ate less food when subsequent meals were offered 30 to 45 minutes after consuming the high-fiber food, indicating a satiety effect (Jewell and Toll, 1996). Other reports support a satiety effect of dietary fiber in dogs and cats (Jackson et al, 1997; LaFlamme and Jackson, 1995; Fekete et al, 2001).

Fiber decreases the apparent digestibility of energy-providing nutrients in the food by 2 to 8% (Levine and Billington, 1994; de Haan et al, 1990; Fahey et al, 1990a; Kelsay et al, 1978; Farrell et al, 1978). Fiber decreases pancreatic enzyme activity in vitro and pancreatic lipase secretion in vivo (Isaksson et al, 1982; Stock-Damge et al, 1983). Fiber also increases the fecal excretion of bile acids and fat (Vahouny, 1987). It is well documented that some dietary fibers slow the absorption rate of carbohydrate and fat, but the total quantity absorbed during the entire period of digestion is not significantly less than the quantity absorbed from fiber-free foods (de Haan et al, 1990; Edwards, 1992; Nelson et al, 1991). Increased dietary fiber decreases the apparent digestibility of dietary protein when fecal nitrogen is measured (de Haan et al, 1990; Fahey et al, 1990a; Kelsay et al, 1978; Farrell et al, 1978). However, it is unclear whether the increased fecal nitrogen is from dietary protein that would normally be digested and absorbed, or whether the nitrogen is from increased numbers of fecal bacteria, endogenous loss of mucosal cells or a component of the fiber itself. The effect of dietary fiber on mineral availability depends on the specific fiber(s) and mineral(s). In general, insoluble fibers such as cellulose are less likely to reduce mineral availability than are soluble fibers (Chapter 5).

Pet owners need to be advised that increased levels of dietary fiber will have noticeable effects on normal defecation habits. Dietary fiber increases the amount of fecal material and frequency of defecation (Vahouny, 1987; Fahey et al, 1990a). Dogs fed soluble fiber produced more feces than dogs fed similar amounts of predominantly insoluble fiber (Fahey et al, 1990). Dogs may not tolerate beet pulp and pectin when fed in amounts greater than 10% (Fahey et al, 1990a) or 13% DM (Nelson et al, 1991). Pet owners should be informed that the quantity of feces the animal produces will probably increase when their cats and dogs are fed foods containing more than 10% DM fiber. Excessive flatus can also be an unwelcomed side effect of feeding high-fiber foods. Fiber solubility roughly equates with fiber fermentability (Chapter 5). Increased amounts of highly fermentable fiber in a food are more likely to result in excessive flatulence than if insoluble fibers are used.

Depending on the combination, mixed fibers would be likely to result in less flatulence than using only soluble fibers and less fecal volume than using only insoluble fibers.

Taken together, study results support the use of dietary fiber in foods intended for weight loss and weight maintenance. For the reasons noted above, most commercial calorie-restricted foods with increased fiber contain primarily insoluble fiber.

The recommended range for fiber content of dog foods intended for weight loss is between 12 and 25% DM; for prevention of weight regain, the range is between 10 to 20% DM. The range for dietary fiber content of cat foods used for weight loss is between 15 and 20% DM; for prevention of weight regain following weight loss, the range is between 6 and 15% DM.

Protein and Amino Acids

Dietary protein has several effects that benefit weight loss. Increased dietary protein and amino acids are necessary for animals undergoing a weight-loss regimen to prevent loss of lean body mass (Hannah and Laflamme, 1998; Bierer and Bui, 2004; Laflamme and Hannah, 2005). Dog foods for weight loss should contain at least 25% DM crude protein (higher is better) to help prevent loss of lean body mass (Jewell and Toll, 2007). Dog foods intended for prevention of weight regain should contain at least 18% crude protein (higher is better). Cat foods for weight loss should contain at least 35% DM crude protein (higher is better) for the same reason. These same values are recommended for prevention of weight regain in cats.

Not only is the amount of protein important in protecting against loss of lean body mass during weight loss, so is the protein quality (Yamka et al, 2007b). The quality of a protein depends on the makeup of its constituent amino acids. When amino acids are used for protein synthesis, each necessary amino acid must be available in adequate amounts. The amino acid that is in the shortest supply is referred to as the first limiting amino acid. The idea of an ideal or perfect protein was first established in swine. The purpose of optimizing the amino acid profile of feeds for swine was to maximize lean tissue and minimize fat in finished swine carcasses. This required determining the first limiting amino acid, usually lysine, then balancing the content of the other essential amino acids in the feed to the lysine content. This resulted in swine feeds with ideal or perfect protein content; protein for which the potential for amino acid antagonism and imbalances were minimized (Chapter 5). The result was a leaner, more readily marketable carcass and more efficient growth. Later, researchers used the same idea for determining the ideal or perfect amino acid profile for dogs and cats (Baker and Czarnecki-Mauldin, 1991).

The use of this technology in foods for overweight dogs has shown promising results in weight loss and maintenance of lean body mass during weight loss. Overweight dogs (>30% body fat) were fed either a commercial veterinary therapeutic weight-loss food (control food) or two experimental weight-loss foods for two months. The control food provided 28% DM protein and 21% DM crude fiber. The two experimental foods were only slightly different and contained about 33.5% DM protein and about 10.5% DM crude fiber; the soluble fiber fraction was increased vs. the control food. The experimental foods also had optimized amino acid ratios based in part on higher lysine content. Compared to dogs fed the control food, dogs fed the experimental foods lost significantly more body weight (-2.1 kg vs. -1.3 kg, respectively) and had better lean body mass responses (approximately +0.3 kg vs. -1.1 kg, respectively) (Yamka et al, 2007b).

The lysine content of a food for weight management is not reflected by crude protein content. Individual ratios of essential amino acids to lysine are useful but are cumbersome to use for key nutritional factor targets. Although not an ideal representation of how "perfect" a food's protein content is, the total amount of lysine in dog foods for weight management is somewhat indicative. The recommended amount of DM lysine in dog foods for weight loss is at least 1.7% (Yamka et al, 2007). Dietary protein stimulates increased postprandial thermogenesis and protein turnover. The heat generated during the postprandial period is approximately 68% greater than that generated from carbohydrate sources. Therefore, when an animal consumes protein, it burns more energy (more heat), which appears to be associated with increased protein turnover (increased protein synthesis). Also, the efficiency of the body to convert protein to ATP via oxidation is decreased substantially when compared to fat or carbohydrate. Thus, less net energy is available when animals consume high-protein compared to high-carbohydrate foods (Laflamme and Hannah, 2005).

Carbohydrates

Carbohydrates are an excellent source of energy in canine and feline foods. There are three main categories of carbohydrates: simple sugars, complex carbohydrates and dietary fiber (Flickinger and Sunvold, 2005) (Chapter 5). The importance of dietary fiber has been discussed above.

Simple sugars and complex carbohydrates (grain sources) have received much attention in human nutrition and weight loss because of their effects on the glycemic index. The glycemic index is a ranking system for carbohydrates based on their immediate effect on blood glucose levels. Similar to effects in people, consumption of different sugars and carbohydrate sources alters postprandial glucose levels and insulin secretory patterns in dogs and cats (Flickinger and Sunvold, 2005; Bouchard and Sunvold, 2000; Nguyen et al, 1998; Sunvold and Bouchard, 1998). As a result, it has been suggested that foods producing low glycemic responses be fed to animals that are diabetic, obese and for the prevention of both conditions. Consumption of foods with a low glycemic index improves blood glucose and lipid control (Nguyen et al, 1998).

In a study that evaluated the effects of feeding five different carbohydrate sources (corn, wheat, barley, rice and sorghum) on glucose and insulin responses in dogs, rice had the highest postprandial glycemic response (i.e., increased postprandial glucose and insulin response). Barley, corn and sorghum were the best carbohydrate sources for dogs with impaired glucose control

(i.e., diabetes and obesity) because of their low-insulinogenic responses (Sunvold and Bouchard, 1998).

Another study evaluated the effects of feeding the same five carbohydrate sources on glucose and insulin responses in cats. Rice had the highest postprandial insulin response and higher glucose levels early in the postprandial period. This study found that barley, corn and sorghum were the best carbohydrate sources for cats with impaired glucose control (Bouchard and Sunvold, 2000). When considering which weight-management food to use in a canine or feline weight-loss program, it is important to evaluate the carbohydrate sources. Based on these data, it is best to avoid foods based primarily on rice when selecting weight-loss foods. Note that the earlier listing of rice on a specific product's ingredient label, the more rice the product contains. Arbitrarily, rice should not be one of the first three or four non-water ingredients on a weight-loss or weight-control food's label (Chapter 9).

The recommended upper limit for DM carbohydrates in foods for weight loss in dogs is 40%; for prevention of weight regain, the upper recommended limit should not exceed 55% DM. For cat foods intended for caloric-restriction weight loss, the DM carbohydrate content should not exceed 35%; for prevention of weight regain, the recommended upper limit should not exceed 40% (DM).

L-Carnitine

L-carnitine is a vitamin-like, amino acid compound present in all animal cells. Biochemically, it is involved in a variety of functions including fat metabolism and energy production (Chapter 6). In food animals during active growth, among other things, L-carnitine improves nitrogen balance, increases protein accretion and reduces fat deposition (Odle et al, 2000).

The food animal industry has long been interested in nutrients that influence partitioning away from body fat and toward muscle deposition. L-carnitine supplementation results include improved nitrogen balance, increased protein accretion and reduced body fat (Gross et al, 1998). In a 12-week study involving obese dogs (>1.3 RBW) fed a dry, low-fat, high-fiber food with or without added L-carnitine, dogs were fed to achieve weight loss equal to 2.5% of their initial obese weight per week. Food, energy and protein intakes were similar in both groups. Although dogs in control and study groups lost similar amounts of weight, the L-carnitine-supplemented dogs maintained lean body mass and had a trend towards greater body weight loss (Gross et al, 1998).

Results were similar in another controlled study of obese dogs (42 to 43% body fat) in a 19-week weight-loss program. Dogs were fed dry, low-fat, high-fiber foods with or without added L-carnitine. In the first seven-week phase of the study, both groups were fed free choice. The L-carnitine-supplemented dogs lost more body weight. During the last 12 weeks of the study, the dogs' food intake was adjusted to provide just less than 1% loss of their initial body weight per week. The L-carnitine-supplemented dogs tended to have a higher lean body mass percentage, lower percent fat mass and lost more weight than the other group (Sunvold et al, 1998, 1999). Another study in healthy obese-prone dogs fed a low-fat, high-fiber, L-carnitine-supplemented food for six months showed similar results (Allen et al, 1998).

Several studies demonstrated the effectiveness of L-carnitine supplementation for overweight cats. One 18-week study of obese (>1.2 RBW) pet cats either supplemented with an aqueous source of L-carnitine or a placebo, were fed a moist, high-protein, low-carbohydrate commercial cat food intended for weight loss. Weight loss was safely achieved in study and control groups; however, the L-carnitine-supplemented cats had significantly more weight loss than the placebo group (Center et al, 2000). In a study involving obese colony-housed cats, cats receiving L-carnitine supplements lost significantly more weight than cats without supplements (both groups were fed a low-fat food) (Ibrahim et al, 2003). Thus, weight-loss foods with supplemental L-carnitine have improved weight-loss performance in overweight dogs and cats.

L-carnitine supplementation during fasting and experimental induction of hepatic lipidosis may be protective (Armstrong et al, 1992; Blanchard et al, 2002).

The recommended level of L-carnitine in foods intended for weight loss in dogs is at least 300 ppm (DM). For cat food intended for weight loss, the recommended level is at least 500 ppm (DM). The recommended levels for prevention of weight regain in dogs and cats are the same as for weight loss.

Antioxidants

Obesity increases oxidative stress, which may also contribute to diseases associated with obesity (Tanner et al, 2006; Sonta et al, 2004; Urakawa et al, 2003). Studies also show supplemental antioxidants help blunt oxidative stress. For example, serum levels of vitamin E and β-carotene were significantly lower in obese children than for normal weight cohorts consuming similar amounts of these nutrients (Strauss, 1999). Obese rats receiving dietary vitamin E supplementation had lowered oxidative stress biomarkers compared to those in similarly supplemented lean rat cohorts (Laight et al, 1999; Blakely et al, 2003). Furthermore, as in other species, antioxidant combinations seem to work best because they participate in networks to regenerate and/or spare each other to extend/improve their positive effects on oxidative stress in dogs and cats (Jewell et al, 2000; Milgram et al, 2002; Devlin et al, 2001). Effective inclusion levels have been studied for vitamins E and C and selenium for their antioxidant benefits in dog and cat foods. Although other sources of antioxidants are available (e.g., carotenoids, thiols and various fruits and vegetables), the following discussion focuses on vitamins E and C and selenium as antioxidant key nutritional factors because: 1) they are biologically important, 2) they act synergistically (e.g., vitamin C regenerates vitamin E after reacting with free radicals), 3) they are safe and 4) information about inclusion levels in pet foods is usually readily available.

VITAMIN E

Vitamin E is the main lipid-soluble antioxidant in plasma, erythrocytes and tissues (NRC, 2006). It functions as a chain-

breaking antioxidant that prevents propagation of free radical damage of biologic membranes. Vitamin E inhibits lipid peroxidation by scavenging lipid peroxyl radicals much faster than these radicals can react with adjacent fatty acids or membrane proteins. Levels of vitamin E higher than recommended requirements confer specific biologic benefits. Based on antioxidant biomarker studies in dogs and cats, for improved antioxidant performance, weight-management foods for dogs and cat should contain at least 400 and 500 IU/kg (DM), respectively (Jewell et al, 2000).

VITAMIN C

Besides regenerating vitamin E, vitamin C (ascorbic acid) also: 1) regenerates glutathione and flavonoids, 2) quenches free radicals intra- and extracellularly, 3) protects against free radical-mediated protein inactivation associated with oxidative bursts of neutrophils, 4) maintains transition metals in reduced form and 5) may quench free radical intermediates of carcinogen metabolism.

Dogs and cats can synthesize required amounts of vitamin C. However, their ability to synthesize vitamin C may be much less than for other mammalian species (Chatterjee et al, 1975). Dogs can rapidly absorb supplemental vitamin C (Wang et al, 2001). In people, high levels of oral vitamin C increased urine oxalate excretion and risk of urolithiasis (Massey et al, 2005). Cats given vitamin C supplements (0, 200, 400 and 1,000 mg/day) had a small progressive reduction of urinary pH from 6.9 to 6.5 (Kienzle and Maiwald, 1998). Moderate supplementation (193 mg vitamin C/kg of food, DM; approximately 10 mg/day) of foods for healthy adult cats with vitamin C did not seem to increase the risk of oxalate production (Yu and Gross, 2005). Supplemental vitamin C (224 mg/kg DM), in combination with supplemental vitamin E and β-carotene improved antioxidant status in dogs (Wedekind et al, 2002). Until more studies are available, for improved antioxidant performance, and in conjunction with recommended levels of vitamin E, weight-management foods for adult dogs and cats should contain at least 100 mg vitamin C/kg DM and 100 to 200 mg vitamin C/kg DM, respectively.

SELENIUM

Glutathione-peroxidase is a selenium-containing antioxidant enzyme that defends tissues against oxidative stress by catalyzing the reduction of H_2O_2 and organic hydroperoxides and by sparing vitamin E. In addition to the antioxidant function of selenium-dependent glutathione-peroxidase, it affects regulation of proinflammatory cytokines including leukotrienes, thromboxanes and prostaglandins, which might benefit the adipokine component of the pathology associated with obesity (**Table 27-2**) (Surai, 2002, 2003). The minimum requirements for selenium in foods for dogs and cats are 0.10 and 0.13 mg/kg (DM), respectively (Wedekind et al, 2002a, 2003, 2003a). Animal studies and clinical intervention trials in people have shown selenium to be anticarcinogenic at much higher levels (five to 10 times) than recommended human allowances or minimal requirements (Combs, 2001; Neve, 2002). Several mechanisms have been proposed for this effect, including enhanced antioxidant activity via glutathione peroxidase (Neve, 2002). Therefore, for increased antioxidant benefits, the recommended range of selenium for weight-management dog and cat foods is 0.5 to 1.3 mg/kg (DM). There are no data to base a safe upper limit of selenium for dogs or cats, but for regulatory purposes, a maximum standard of 2.0 mg/kg (DM) has been set for dog foods in the United States (AAFCO, 2007).

SODIUM AND PHOSPHORUS

Dogs and cats that are overweight may be experiencing some degree of hypertension (See Health Risks of Obesity discussion, above and **Table 27-1**). Also, because they may be fed weight-management foods for extended periods of time, and subclinical renal disease is relatively common, sodium and phosphorus levels in weight-management foods are important. Therefore, the recommendations for sodium in foods for weight management in dogs and cats are 0.2 to 0.4% and 0.2 to 0.6% (DM), respectively. The recommended phosphorus levels for weight-management foods for dogs and cats are 0.4 to 0.8% and 0.5 to 0.8% (DM), respectively.

Key Nutritional Factors: Metabolic-Control Foods for Weight Loss in Cats

The use of metabolic-control foods is an alternative to calorie-control foods for weight loss in overweight cats. This approach is similar to the "low carb" human weight-loss programs that have resurged in popularity. The first low-carbohydrate diet that enjoyed popular success in people was used in the 1860s (Bravata et al, 2003). Contemporary variations on the low-carbohydrate theme for people include programs such as the Atkins and South Beach diets. The metabolic approach to weight loss in cats is probably more like the South Beach diet in that it is less restrictive in carbohydrate and lower in fat than the Atkins diet approach. Although the popular emphasis is on lowering carbohydrate intake, both the Atkins and South Beach diets rely on a multifaceted approach. Dietary protein is also important, as with traditional calorie-restricted foods discussed above. The South Beach diet recommends less fat, lower glycemic index carbohydrate sources and, to a lesser extent, increased dietary fiber. The basic premise of the metabolic approach is to shift energy metabolism from energy storage to energy use.

Clinical trials have shown the efficacy of metabolic-control foods to be equivalent to traditional low-calorie foods for safe weight loss in cats.[a] The key nutritional factors for metabolic-control cat foods for weight loss are discussed below and summarized in **Table 27-6**.

Carbohydrate

Limiting dietary carbohydrate is an important component of metabolic control for weight loss. There are three key advantages to limiting dietary carbohydrate to 20% (DM) or less: 1) lower glycemic index, 2) metabolic shift from energy storage to energy usage and 3) increased satiety.

As discussed for the key nutritional factors for calorie-

Table 27-6. Key nutritional factors for metabolic-control cat foods for weight loss.

Factors	Dietary recommendations (dry matter basis)
Carbohydrate	≤20%
Protein	At least 47% but not exceed 55%
Fat	≤25%
Fiber	≥5%
L-carnitine	≥500 ppm
Antioxidants	Foods for weight loss and prevention of weight regain should contain:
Vitamin E	≥500 IU vitamin E/kg
Vitamin C	100 to 200 mg vitamin C/kg
Selenium	0.5 to 1.3 mg selenium/kg
Sodium	Foods for weight loss should contain between 0.2 to 0.6%
Phosphorus	Foods for weight loss should contain between 0.5 to 0.8%

restricted foods, simple sugars and complex carbohydrates (i.e., grain sources) have received much attention in human weight-loss programs because of the known effects of various carbohydrates on the glycemic index. As in people, consumption of different sugars and carbohydrate sources alters postprandial glucose levels and insulin secretory patterns in cats and dogs (Flickinger and Sunvold, 2005; Bouchard and Sunvold, 2000; Nguyen et al, 1998; Sunvold and Bouchard, 1998). Therefore, foods producing low glycemic responses should be recommended for obese or diabetic patients.

The stimulatory effect of increased carbohydrate intake on insulin secretion provides for a metabolic shift to support fat deposition, given the potent lipogenic effects of insulin. In contrast, low-carbohydrate foods, particularly in combination with fat, protein and fiber, result in a more blunted insulin response that helps set the stage for fat use. Also, as discussed above, by using less available carbohydrate sources, the glycemic index can be modified to further shift energy use to be more dependent on amino acids (protein), fat and ketones. Furthermore, in the calorie-restriction approach to weight loss, different sugar and starch sources variably affect postprandial glucose levels and insulin secretory patterns in cats (Bouchard and Sunvold, 2000). Carbohydrate sources that result in a lower glycemic index are more desirable for metabolic weight control. Compared to barley, corn and sorghum, rice as a starch source produces the highest glycemic index in cats. Therefore, as with energy-restricted foods, it is probably best if rice is not one of the first three or four non-water ingredients on the product's label (Chapter 9).

A reduced ratio of dietary carbohydrate to protein in people has a satiety effect (Layman et al, 2003). Lowering the glycemic index could have an effect on satiety because a rapid increase in blood glucose typically evokes an equally intense insulin response that can lead to a period of hypoglycemia followed by hunger. In people, this occurs approximately two hours after a meal (Roberts, 2000). However, increasing protein can also have a satiety effect (see below). The satiety effect of a reduced dietary carbohydrate to protein ratio may be due to both components.

For metabolic weight-loss foods for cats, dietary digestible carbohydrates should not exceed 20% (DM); lower is probably better. When foods containing this level of dietary carbohydrate in combination with increased protein and moderate fat are fed in appropriate amounts, they result in controlled weight loss in cats (Butterwick and Markwell, 1994, 1996).[a]

Protein

Cats have an innate metabolic capacity to readily use protein (amino acids) for energy (Chapter 19). The natural diet of cats is primarily animal tissue and contains only small amounts of digestible carbohydrate. Cats, therefore, typically have lower levels of hepatic glucokinase than do omnivorous species and have higher levels of transaminases and deaminases that do not down regulate, even when protein intake is reduced. Thus, cats have a higher protein requirement and are metabolically geared to use protein for energy. Cats rely heavily on glucogenic amino acids to generate glucose for glucose-dependent tissues (Macdonald et al, 1984) (Chapter 19).

Increasing its protein content can reduce the carbohydrate content of a food. As discussed for the key nutritional factors for the energy-restriction approach to weight loss, relying on dietary protein as a major energy source has beneficial metabolic effects for weight loss. These effects include reduced energy efficiency, satiety effects and preservation of lean body mass.

In people, increasing a food's protein content increases its thermic and satiety effects (Crovetti et al, 1998). The TEF is the obligatory cost of digesting and absorbing food. TEF constitutes approximately 10% of total expenditure. Thus, increasing a food's thermic effect reduces its energy efficiency (Danforth, 1985; Horton, 1983). In a human study, 10 people received, in randomized order, high-protein, high-fat and high-carbohydrate meals. The high-protein meal was the most thermogenic ($p < 0.001$) and it determined the highest sensation of fullness ($p = 0.002$). There were no differences in the sensation and thermic effects between the high-fat and high-carbohydrate meals. A significant relationship linked TEF to fullness sensation ($r = 0.41$, $p = 0.025$) (Crovetti et al, 1998).

Increasing the dietary protein level during weight loss spares lean body mass. In one study in cats, 47% DM dietary crude protein preserved lean body mass during controlled weight loss (1% per week). In this study, weight loss did not differ significantly between cats fed a high-protein food and those fed a control food with less protein. However, the high-protein group had significantly greater loss of body fat and significantly less loss of lean body mass (Laflamme and Hannah, 2005).

Theoretically, prolonged, excessive protein intake poses some risks. Consumption of high-protein diets in people (i.e., two to three times the U.S. Recommended Daily Allowance) increases urinary calcium loss and may, over time, predispose to bone loss (Eisenstein et al, 2002). However, cats have a relatively high protein requirement because of their obligatory use of amino acids in gluconeogenesis (Chapter 19) and are well adapted to using dietary protein. The protein require-

ment for an adult cat is twice as much as that for an adult dog (NRC, 2006).

The recommended dietary protein level for cat foods for metabolic-control weight loss is at least 47%, but should probably not exceed 55% (DM).

Fat

When dietary digestible carbohydrate is limited, cats rely more on fat as an energy source. This approach, to a degree, mimics fasting metabolism. During fasting, carbohydrate intake is interrupted and plasma insulin levels decrease while glucagon levels increase. Body fat is then stimulated to release long-chain fatty acids that are transported to the liver where some are converted to ketones, which can be used as energy to fuel hepatic gluconeogenesis. Those ketones not used by the liver are released into the bloodstream for use by peripheral tissues, some of which cannot use long-chain fatty acids for fuel. Fasting ketosis is physiologic and is not harmful because ketones do not reach the level they do during diabetic ketoacidosis (Bruss, 1997). Typically, fasting ketosis results in ketone levels of only 7 to 20% of the levels associated with diabetic ketoacidosis. Thus, low dietary carbohydrate intake sets the stage for a greater reliance on fat and protein for energy usage. Ketones reduce protein catabolism, which may in part explain the preservation of lean body mass observed when low-carbohydrate/high-protein foods are used for weight loss (Volek and Westman, 2002).

In cats, high dietary fat, low-carbohydrate intake (29.5 and 11.8%, DM, respectively) results in a lower glycemic index than low dietary fat, high-carbohydrate intake (15.1 and 38.4%, DM, respectively). Higher dietary fat also reduces the digestibility of the carbohydrate portion of the food (Thiess et al, 2004). However, as has been discussed, dietary fat provides considerably more energy per unit weight than does protein or carbohydrate. Therefore, as in energy-restricted foods, dietary fat levels in metabolic weight-loss foods should be kept as low as possible. However, metabolic-control foods containing 20% fat (DM) have achieved weight-loss performance equivalent to that of low-fat, energy-restricted foods.[a]

Thus, dietary fat should not exceed 25% (DM).

Fiber

Dietary fiber promotes weight loss by diluting calories, increasing satiety and limiting food consumption due to more bulk in the GI tract (Levine and Billington, 1994). Fiber may also help produce weight loss by decreasing the availability of calories by interfering with the digestion and absorption of fat, protein and digestible carbohydrate (Levine and Billington, 1994). Refer to the fiber discussion above in the Key Nutritional Factors: Calorie-Controlled Foods for Weight Loss and Prevention of Weight Regain in Dogs and Cats section, for detailed information about the advantages of dietary fiber in weight-loss foods. Inclusion of fiber in metabolic-control foods for weight loss in cats allows for further reduction of digestible carbohydrate and/or fat content.

Dietary fiber levels in metabolic-control foods for weight loss in cats should be at least 5% (DM).

L-Carnitine

L-carnitine nutriture is important for safe weight loss in overweight cats (see expanded discussion of L-carnitine in the Key Nutritional Factors: Calorie-Controlled Foods for Weight Loss and Prevention of Weight Regain in Dogs and Cats section, above). Adequate intake of L-carnitine protects against the development of hepatic lipidosis and improves weight-loss performance in cats fed high-protein, low-carbohydrate, low-fat foods (Center et al, 2000). The recommended level of dietary L-carnitine should be at least 500 ppm.

Antioxidants

Because oxidative stress is increased in overweight patients and oxidative stress contributes to diseases associated with obesity, supplemental antioxidants are recommended for weight-loss foods. Also, combinations of antioxidants are more effective in relieving oxidative stress than are individual antioxidants. Thus, for improved antioxidant performance, weight-loss foods for cats should contain at least 500 IU vitamin E/kg DM (Jewell et al, 2000); 100 to 200 mg vitamin C/kg DM and 0.5 to 1.3 mg selenium/kg DM. (See the Antioxidant section in the Key Nutritional Factors: Calorie-Controlled Foods for Weight Loss and Prevention of Weight Regain in Dogs and Cats section, above.)

Sodium and Phosphorus

Overweight cats may also be experiencing some degree of hypertension. (See Health Risks of Obesity discussion, above and **Table 27-1**.) Also, because these patients may be fed weight-management foods for extended periods of time, and subclinical renal disease is relatively common (Chapters 20, 21 and 37), sodium and phosphorus levels in metabolic weight-control foods are important. Therefore, the recommendations for sodium and phosphorus in foods for metabolic weight loss for cats are 0.2 to 0.6% (DM) and 0.5 to 0.8% (DM), respectively.

FEEDING PLANS FOR OVERWEIGHT AND OBESE DOGS AND CATS

Weight Reduction

A successful weight-reduction program is a multi-step process that requires: 1) pet owner commitment (**Box 27-7**), 2) proper food, 3) an appropriate feeding method, 4) an exercise plan (**Box 27-8**), 5) pet owner communication (**Box 27-9**) and 6) patient monitoring (reassessment). This six-step program is listed in **Figure 1**, **Box 27-9**.

In people, the combination of reduced-calorie foods, regular exercise and behavior modification has the greatest chance of achieving and maintaining weight loss (Wilson, 1990; Vasselli et al, 1983; Leaf, 1990; Caterson, 1990; Council on Scientific Affairs, 1988). For overweight dogs and cats, formulation of a program for achieving weight reduction consists first of select-

Box 27-7. Obtaining Pet Owner Commitment.

An important step in a successful weight-loss program is for everyone who feeds the pet to recognize, accept and understand the reason why the pet should lose weight, and to make a commitment to accomplish that goal. Satisfactory weight loss is unlikely to occur unless the pet owners recognize the problem and are committed to take corrective steps. Such commitment will greatly improve compliance (Chapter 3) with a feeding plan and increase the likelihood of a successful outcome. The good news is that owners care whether or not their pets are overweight as evidenced by the results of a survey of cat owners: more than 90% said that maintaining their pets' proper weight was important or extremely important.[a]

Several techniques can be used to help owners recognize and accept that their pet is overweight and not just "stocky." Some of these techniques have already been discussed in the accompanying chapter. Past body weights and body condition scores (BCS) in the patient's medical record can be used along with relative body weights to show an owner how excessive present body weight relates to the animal's frame size and optimal body weight (Appendices 14 and 15). BCS illustrations may help (Chapter 1). Because they typically underestimate their pets' body condition, owners should be taught to feel where bony structures should be readily palpable but are not, and where body contours differ from optimal. The BCS can be used to estimate percent body fat; for additional body composition information, see **Table 27-3**.

If thoracic or abdominal radiographs have been taken, a side-by-side comparison with similar radiographic views from an animal of similar size at optimal body weight can quite effectively demonstrate to the owner the pet's excess subcutaneous or intra-abdominal fat (**Figures 1** and **2** in **Box 27-2**). Practitioners should consider keeping a reference set of radiographs for cats and dogs in optimal body condition for this specific purpose. Also, a side-by-side comparison of the overweight animal and one of the same breed and frame size in optimal body condition can serve the same purpose if an animal of optimal weight is available. Sequential dual energy x-ray absorptiometry scans can also be used for this purpose.

A free web-based program is available in which the patient's silhouette is matched to a dog/cat visual and an ideal weight is automatically calculated; this program could also be a persuasive aid (**Box 27-10**).

After the owners recognize and accept that the pet is overweight, the next step is for them to commit to a weight-loss program. There are several strategies to help owners make this commitment. Owners can be informed about documented problems associated with obesity and how returning the animal to optimal weight will reduce the risk of one or more of these problems. The risks can be quantified economically for animals likely to suffer orthopedic or metabolic problems because of their degree of obesity. Often, a strong motivating factor for commitment is to improve or even resolve a problem caused or exacerbated by obesity. Weight loss in these cases becomes part of the overall therapeutic plan and can be crucial for realizing clinical improvement and benefit from other treatments.

ENDNOTE

a. Weight Management Study, Pet Owner Summary #D02-284. Hill's Pet Nutrition, Inc. September 2002.

The Bibliography for **Box 27-7** can be found at www.markmorris.org.

ing a specific food and determining the feeding method. The feeding method includes setting a goal for the amount of weight to lose and determining how much of the new food to feed to achieve the weight loss. Although not a nutritional consideration, obtaining owner agreement about a realistic exercise plan should be part of the process. Reassessment of the weight-loss part of weight management should include monitoring the progress of weight loss and, as necessary, adjusting food intake and exercise to achieve the agreed upon weight-loss goal. Finally, it is very important to stabilize caloric intake of the animal at its reduced weight to ensure that weight is not regained.

Assess and Select the Food for Weight Reduction

The calorie-restriction strategy should be used for overweight dogs and, initially, for overweight cats. **Tables 27-7** for dogs and **27-8** for cats compare the key nutritional factor targets to the key nutritional factor content of selected commercial veterinary therapeutic foods marketed for weight loss. Select the food that is most similar to the key nutritional factor targets and/or has the best efficacy evidence for managing weight loss in dogs or cats (Roudebush et al, 2008).

If an energy-restriction strategy has been tried in cats, but has not achieved the desired weight loss, a metabolic weight-loss program should be considered. **Table 27-9** compares the key nutritional factor targets to the key nutritional factor content of available veterinary therapeutic cat foods marketed for a metabolic approach to weight loss. Again, select the food that is most similar to the key nutritional factor targets and/or has the best efficacy data (Roudebush et al, 2008).

Another criterion for selecting a food that may become increasingly important in the future is evidence-based clinical nutrition. Practitioners should know how to determine risks and benefits of nutritional regimens and counsel pet owners accordingly. Currently, veterinary medical education and continuing education are not always based on rigorous assessment of evidence for or against particular management options. Still, studies have been published to establish the nutritional benefits of certain pet foods. Chapter 2 describes evidence-based clinical nutrition in detail and applies its concepts to various veterinary therapeutic foods.

Ideally treats, snacks and human foods should be eliminated from the feeding plan to maximize the chances for successful

Box 27-8. Exercise and Environmental Enrichment Programs as Part of a Weight-Loss Plan.

Moderate, regular exercise is advocated in all pet weight-management programs because increased physical activity can enhance weight loss. Exercise is the only practical means of increasing energy expenditure to create or widen a deficit between energy consumed and energy expended for overweight patients. The metabolic rate of people undergoing weight reduction decreases more than expected after corrections have been made for decreased thermogenic effects of food due to decreased intakes and decreased resting energy requirement (RER) due to loss of lean body mass. The only way to successfully sustain or increase overall energy expenditure during weight reduction is to increase the amount of physical activity. Exercise may also benefit obese patients by supporting retention of lean body mass and maintaining or increasing RER. In some cases, pets fail to lose weight unless exercise is part of the weight-reduction plan, regardless of the severity of caloric restriction. Thus, modifying physical activity has been a key target of behavioral intervention to change body weight in people and pets.

Besides increasing energy expenditure, moderate, regular physical activity can help regulate food intake and improve lean body mass. This seems to hold true for weight-loss and weight-maintenance programs. Exercise improves insulin sensitivity, partially reverses leptin resistance and suppresses the enhanced proinflammatory burden induced by obesity. In obese people, physical activity appears to have an independent effect on health-related outcomes compared to body weight. It is unknown if exercise creates beneficial health effects in obese or overweight pets independent of weight loss.

In people, exercise appears to be critical for prevention of significant weight gain and maintenance of weight loss. In dogs, the risk of obesity appears to decrease with each hour of weekly exercise. Owners of overweight cats play less with their cats than do owners of normal weight cats. In people, concomitant changes in food and exercise are more important in women than men.

Specific recommendations for increasing exercise should consider the patient's previous level of activity, presence of any physical problems for which exercise is contraindicated and time constraints of the owner.

For dogs, 15- to 30-minute walks at least five to seven times per week are recommended. Up to an hour of walking has been reported to be practical and enjoyable for some owners and pets. The daily energy requirements of dogs covering 5 km per day are estimated to increase between 7 to 15%. Exercise should be implemented gradually, starting with amounts the patient can comfortably tolerate, especially if orthopedic, cardiovascular or pulmonary disease is also present. It is more important that the animal increase its activity by some amount each day even if it initially is able to walk only out the door to the sidewalk and back inside. The goal should be to work up to 15 to 30 minutes of uninterrupted walking if the animal cannot do this initially. Exercise may need to be omitted initially for patients recovering from orthopedic surgery because walking may exacerbate joint pain. Swimming is an alternative to walking that sometimes works for orthopedic patients if facilities are available to the owner. Because swimming uses more calories per minute than walking, the same number of calories can be expended in less time (5- to 15-minute swim vs. 15- to 30-minute walk).

Some creativity is often required to increase the activity of an overweight cat. Although cats do not readily walk on a leash, they can be trained to do so if the owner is patient and persistent. Sometimes a cat will walk back home on a leash if an exceptionally dedicated owner is willing to carry the cat on the out-bound half of the walk. The type of harness used for cats to be walked on a leash should be secure so the cat cannot escape the leash. This can be a challenge. Less extraordinary ways of increasing a cat's daily activity are to engage the cat in supervised play with string, balls, laser "mice," other toys or other pets. Such methods can make a difference. In a study of overweight cats, encouragement to play and environmental enrichment increased activity enough to cause a 1% loss in body weight over a four-week period.

Options exist for indoor cats to safely be outdoors. Being outdoors provides cats with more opportunity for spontaneous exercise, compared to that which occurs with their typical indoor lifestyle. Such experiences have the additional benefit of environmental enrichment. The outdoor options for indoor cats include a wide variety of pet doors and safe cat-proof fencing. **Table 1** provides a partial listing of websites for doors and fencing; internet searches and pet supply stores are additional sources.

Environmental enrichment can be important to a weight-loss program. A recent study evaluated the effects of environmental enrichment on weight loss in cats. Cat owners were given feeding guidelines to reduce their obese cats' body weight and were randomly assigned to either include environmental enrichment or not. Enrichments included additional food dishes, water bowels and litter boxes, plus climbing towers, window perches, scratching posts, cat spas, grooming supplies and toys. Cats were weighed weekly and some were monitored for activity levels. Environmentally enriched cats had increased activity levels and a trend towards increased weight loss. Owners of the environmentally enriched cats had a more positive image of their cat and felt they were playing a more active role in their cat's weight loss.

There may also be benefits when people and pets exercise together during weight loss. In one study, people exercising with their dogs reported a significantly improved quality of life for themselves and a combined dog/owner weight-loss program was more effective at maintaining participation in a canine weight-loss program.

Table 1. Cat doors and cat-proof fencing.

Websites for cat doors
Catdoors.com
Petdoors.com
Solopetdoors.com
Websites for cat fences
Catfence.com
Catfencein.com
Feralcat.com/fence.html
Purrfectfence.com
Websites for electronic cat fences
Hitecpet.com
Radiofence.com

The Bibliography for **Box 27-8** can be found at www.markmorris.org.

weight loss. A portion of the total daily calories for weight loss (10% or less) can be reserved if the owner insists on feeding treats or snacks (Yaissle et al, 2004). Some treats are specifically formulated for use in veterinary patients and are appropriate for overweight pets (**Table 27-10**). Treats can also be low-calorie foods such as the dry form of the reducing food, popcorn (air popped), low-fat, low-starch vegetables or low-fat commercial treats. The calories supplied by the treats must be accounted for within the total calories allowed in the feeding plan. (See below.) Cats in a metabolic weight-loss program should not receive treats, unless the treats conform nutritionally to the key nutritional factor content of the food.

Assess and Determine the Feeding Method for the Weight-Reduction Program

Feeding method considerations include determining the amount of food to feed for weight loss and selecting the way the food is fed. Determining the amount of food to feed is essential to the success of the plan and is based on the estimate of caloric restriction necessary to safely achieve weight loss. If body fat were the only tissue component lost during weight reduction, then simply starving dogs, *but not cats*, would be an acceptable option for weight loss from a strictly physiologic perspective. There are several disadvantages; however, to using starvation for weight reduction in dogs including loss of lean body mass; therefore, it is not recommended (Burkholder and Toll, 2000).

Even when body weight is lost using more conventional weight-loss programs, 10 to 25% of the loss comes from lean tissues (Burgess, 1991; Butterwick and Markwell, 1996). This loss of lean body mass ultimately decreases an animal's RER and the number of calories required for DER, unless the level of activity is increased to that associated with athletic training. Therefore, one underlying objective in setting the number of daily calories for weight loss is to restrict calories enough to produce weight loss, but still provide enough calories, protein, vitamins and minerals to prevent or minimize nutrient deficiencies and subsequent loss of lean body tissue. As mentioned above, foods properly formulated for weight loss minimize loss of lean body mass (See Assess and Select the Food section above).

Studies in people indicate that loss of more than 2% of body weight per week is unhealthy (Weinsier et al, 1984, 1995). A greater proportion of lean body mass is lost when more than 2% of body weight is lost per week. This ultimately reduces the RER and works against the goal of maintaining the greatest metabolic rate possible in a patient undergoing weight reduction. A 2% loss of initial body weight per week is a reasonable estimate of the maximum acceptable rate of weight loss. However, the impact of losing more than 2% of the initial body weight per week on the proportion of fat vs. lean tissue loss and on the metabolic rate has not been reported from weight-loss studies using dogs or cats. Very few animals fed reduced-calorie foods by the methods discussed above will lose more than 2% of their initial body weight per week. At the other extreme, a rate of loss of at least 0.5% of the initial body weight per week is needed to maintain owner interest and complete the weight-reduction program within a reasonable period. When weight is lost at the rate of 0.5% per week, it may take a year or more to achieve the target body weight, especially in cats. Owners should be apprised of this to manage their expectations and maintain their involvement.

How to Estimate the Amount of Food to Feed for Controlled Weight Loss

Several methods exist for determining the caloric need, and therefore, the quantity of food necessary for weight loss. Four of the more common methods are reviewed below. They are recommended for energy-restricted foods for dogs and energy-restricted and metabolic weight-loss foods for cats. They include: 1) using product information, 2) calculations based on estimated ideal weight, 3) calculations based on current food intake and 4) calculations based on current (obese) weight. All generate estimates, and thus, should be considered starting points, which will likely need adjustment with time. For dogs, the goal is an average weight loss of 1 to 2% of the obese body

Box 27-9. Pet Owner Communication.

Educating pet owners about obesity is important to the successful outcome of weight-control programs. Clients usually enroll their pets in weight-loss programs because of veterinary recommendation, access to support and supervision by the hospital's health care team and the perception that weight loss will improve their pet's health. Retention in a weight-loss program improves when the program includes daily recording of food intake in a diary by the client and scheduling regular trips to the hospital for progress checks. However, there is a point of diminishing returns. Owner education programs that provide monthly classes for nutrition-related topics failed to improve average weight loss or body condition scores compared to weight-control programs without the monthly classes. An obesity-treatment program that included an appropriate feeding plan and monthly hospital rechecks during weight-loss and subsequent weight-maintenance periods was sufficient to achieve good results.

Recommendations for feeding, exercising and rechecking the patient need to be provided in clear, concise terms. These directions should be verbal and written, and the owner should be able to demonstrate understanding by verbal recall. Pet food companies have brochures that explain obesity and its associated health risks. Some brochures provide space to write individual instructions for feeding, exercise and recheck appointments and provide ways of visually documenting progress (**Table 1**). A veterinary practice may also elect to design and distribute its own printed or computer-generated material for this purpose.

The Bibliography for **Box 27-9** can be found at www.markmorris.org.

Box 27-9 continued

Table 1. Canine and feline fact and monitoring sheet.

Customized Pet Weight-Loss Plan

A weight-reduction program has been designed to improve your pet's quality of life. An optimal body weight, specific food(s) and amount(s) have been determined for your pet, along with a recommended exercise regimen.

To successfully manage a weight-reduction program for your pet, you should:

1. Feed only the prescribed food(s).
2. Feed your pet alone; away from other pets.
3. Do not feed table scraps, treats, snacks or other food unless your veterinary health-care team approves them and the amount(s) to be fed.
4. Exercise your pet as prescribed.
5. Do not handle, prepare or eat food in the presence of your pet.
6. Have your pet rechecked on a regular basis by a member of your veterinary health-care team to monitor progress of the weight-loss program.

To be filled out by your veterinary health-care team:

Patient's name_____ Dog___ Cat___

Beginning date: _____/_____/_____

Beginning body weight: _____lb/kg Target (optimal) body weight _____ lb/kg

Prescribed food(s)_____

Amount of food per meal _____ Number of meals per day_____

Amount and type of exercise per day _____

Estimated time to reach optimal weight *if all instructions are followed* _____months

Weigh your pet every _____weeks, and record the weight in the chart below.

Weight Loss Chart

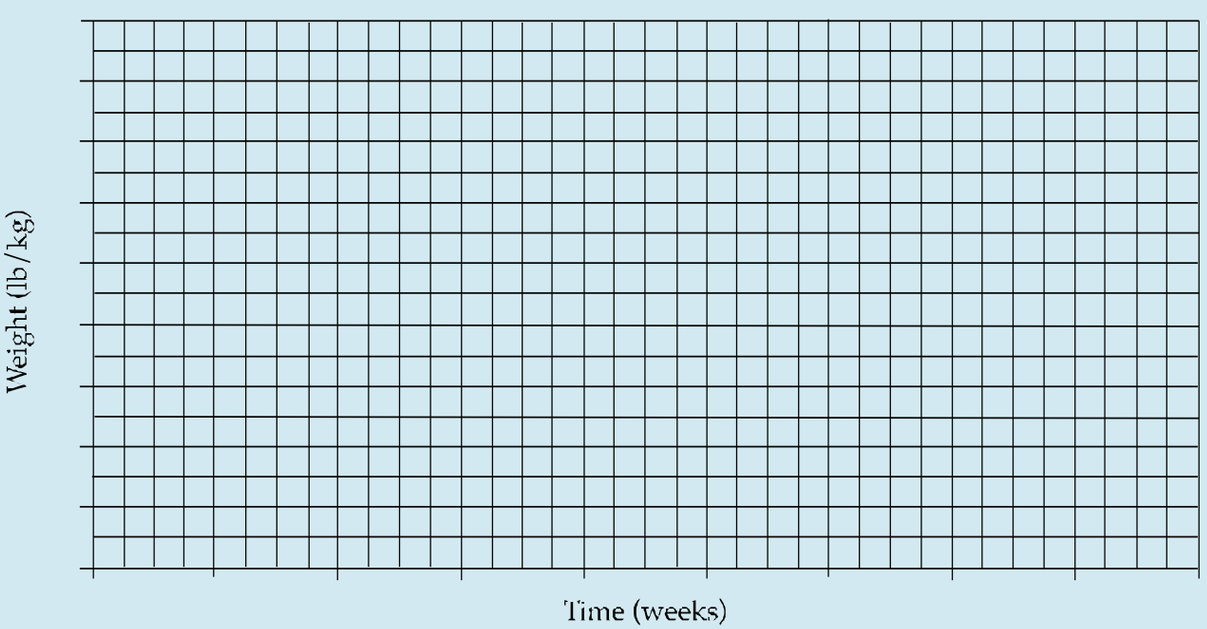


Table 27-7. Levels of key nutritional factors in selected commercial foods marketed for calorie-restricted weight loss in dogs compared to recommended levels.*

Dry foods	Energy density (kcal/cup)**	Energy density (kcal ME/g)	Fat (%)	Fiber (%)	Prot (%)	Lys (%)	Carb (%)	Carn (ppm)	Vit E (IU/kg)	Vit C (mg/kg)	Se (mg/kg)	Na (%)	P (%)
Recommended levels	-	**≤3.4**	**≤9**	**12-25**	**≥25**	**≥1.7**	**≤40**	**≥300**	**≥400**	**≥100**	**0.5-1.3**	**0.2-0.4**	**0.4-0.8**
Hill's Prescription Diet r/d Canine	242	3.3	8.2	13.5	34.3	1.91	38.7	301.1	618	262	1.37	0.24	0.66
Hill's Prescription Diet r/d with Chicken Canine	241	3.3	8.8	13.6	35.2	1.86	36.0	300.0	620	266	1.49	0.40	0.75
Iams Veterinary Formula Weight Control D/ Optimum Weight Control	209	3.5	9.5	3.0	28.7	na	51.2	na	na	na	na	0.51	1.0
Iams Veterinary Formula Weight Loss/Restricted-Calorie	217	3.7	9.1	2.4	25.0	na	58.0	na	na	na	na	0.24	0.83
Medi-Cal Calorie Control	238	na	10.4	4.1	30.2	na	na	na	na	na	na	0.4	1.4
Medi-Cal Fibre Formula	266	na	10.6	14.3	26.2	na	na	na	na	na	na	0.3	0.9
Purina Veterinary Diets OM Overweight Management	266	3.0	7.2	10.3	31.1	na	44.2	na	na	na	na	0.31	0.89
Royal Canin Veterinary Diet Calorie Control CC 26 High Fiber	232	3.1	10.4	17.6	30.9	1.37	33.7	na	962	na	0.33	0.33	0.77
Royal Canin Veterinary Diet Calorie Control CC 32 High Protein	234	3.9	10.4	3.3	37.4	1.42	38.6	na	962	na	0.38	0.38	1.42
Moist foods	**Energy density (kcal/can)****	**Energy density (kcal ME/g)**	**Fat (%)**	**Fiber (%)**	**Prot (%)**	**Lys (%)**	**Carb (%)**	**Carn (ppm)**	**Vit E (IU/kg)**	**Vit C (mg/kg)**	**Se (mg/kg)**	**Na (%)**	**P (%)**
Recommended levels	-	**≤3.4**	**≤9**	**12-25**	**≥25**	**≥1.7**	**≤40**	**≥300**	**≥400**	**≥100**	**0.5-1.3**	**0.2-0.4**	**0.4-0.8**
Hill's Prescription Diet r/d Canine	257/12.3 oz.	3.0	8.6	21.2	25.3	1.39	39.2	370.9	731	131	0.86	0.24	0.53
Iams Veterinary Formula Weight Loss/Restricted-Calorie	397/14 oz.	3.9	14.9	3.2	34.4	na	40.8	na	na	na	na	0.46	0.93
Medi-Cal Calorie Control	212/360 g	na	23.2	1.6	59.2	na	na	na	na	na	na	1.2	1.7
Medi-Cal Fibre Formula	350/396 g	na	9.1	15.0	24.8	na	na	na	na	na	na	0.5	0.8
Purina Veterinary Diets OM Overweight Management	189/12.5 oz.	2.5	8.4	19.2	44.1	na	21.7	na	na	na	na	0.28	1.06
Royal Canin Veterinary Diet Calorie Control CC High Fiber	346/14 oz.	3.6	12.5	8.8	25.9	1.48	46.3	na	271	na	0.41	0.53	0.62
Royal Canin Veterinary Diet Calorie Control CC High Protein in Gel	263/12.7 oz.	4.8	28.5	3.0	51.5	3.1	5.1	na	396	na	na	0.99	1.58

Key: ME = metabolizable energy, na = information not available from manufacturer, Fiber = crude fiber, Prot = protein, Lys = lysine, Carb = digestible carbohydrate, Carn = L-carnitine, Se = selenium, Na = sodium, P = phosphorus, g = grams.
*From manufacturers' published information or calculated from manufacturers' published as-fed values; all values are on a dry matter basis unless otherwise stated.
**Energy density values are listed on an as fed basis and are useful for determining the amount to feed; cup = 8-oz. measuring cup.
To convert to kJ, multiply kcal by 4.184.

weight per week until the patient reaches the desired weight. Also, in dogs, as in people, gradual weight loss is more likely to result in maintenance of the target body weight, once achieved (Laflamme and Kuhlman, 1995).

For cats, a safer and more realistic goal is 0.5 to 1% per week. Again, a weight loss of 0.5% per week for either dogs or cats is acceptable as long as the owner knows that it will take much longer to achieve the desired results.

PRODUCT INFORMATION

For dogs and cats, the simplest and probably the most common method for determining the amount to feed for weight loss is to obtain the food dose recommendation from the company that manufactures the food. This information may be available on the product label, from published company literature, on the company website or by using "calculators" or proprietary software programs. However, the last method often requires an estimate of the patient's ideal or optimal weight. Free web-based programs are available for estimating ideal weight (**Box 27-10**). A simple way to estimate ideal body weight is to use **Table 27-3**. This is accomplished by correlating the patient's current weight with its current BCS and then finding the weight in the same line that corresponds to the ideal BCS (3/5). This and other methods are listed in **Table 27-11**.

Table 27-8. Levels of key nutritional factors in selected commercial foods marketed for calorie-restricted weight loss in cats compared to recommended levels.*

Dry foods	Energy density (kcal/cup)**	Energy density (kcal ME/g)	Fat (%)	Fiber (%)	Prot (%)	Carb (%)	Carn (ppm)	Vit E (IU/kg)	Vit C (mg/kg)	Se (mg/kg)	Na (%)	P (%)
Recommended levels	-	**≤3.4**	**≤10**	**15-20**	**≥35**	**≤35**	**≥500**	**≥500**	**100-200**	**0.5-1.3**	**0.2-0.6**	**0.5-0.8**
Hill's Prescription Diet r/d Feline	263	3.3	9.3	13.6	36.9	33.5	538.6	614	80	0.66	0.35	0.81
Hill's Prescription Diet r/d with Chicken Feline	266	3.4	9.8	13.8	37.7	32.2	556.3	716	120	0.70	0.35	0.84
Iams Veterinary Formula Weight Control D/ Optimum Weight Control	326	3.8	12.2	1.5	38.6	41.2	na	na	na	na	0.39	1.01
Iams Veterinary Formula Weight Loss/Restricted-Calorie	268	3.7	11.0	2.5	35.2	44.5	na	na	na	na	0.37	0.92
Medi-Cal Calorie Control	230	na	9.7	5.1	43.5	na	na	na	na	na	0.8	1.3
Medi-Cal Fibre Formula	280	na	12.2	14.9	34.2	na	na	na	na	na	0.5	0.8
Medi-Cal Reducing Formula	250	na	9.6	5.2	41.8	na	na	na	na	na	0.3	1.2
Purina Veterinary Diets OM Overweight Management Feline Formula	321	3.6	8.5	5.6	56.2	22.4	na	693	116	na	0.57	1.19
Royal Canin Veterinary Diet Calorie Control CC 29 High Fiber	251	3.3	10.2	14.0	33.5	34.5	na	1,065	na	0.32	0.51	0.81
Royal Canin Veterinary Diet Calorie Control CC 38 High Protein	235	3.7	10.2	4.2	43.5	31.5	na	1,124	na	0.38	0.70	1.40
Moist foods	**Energy density (kcal/can)****	**Energy density (kcal ME/g)**	**Fat (%)**	**Fiber (%)**	**Prot (%)**	**Carb (%)**	**Carn (ppm)**	**Vit E (IU/kg)**	**Vit C (mg/kg)**	**Se (mg/kg)**	**Na (%)**	**P (%)**
Recommended levels	-	**≤3.4**	**≤10**	**15-20**	**≥35**	**≤35**	**≥500**	**≥500**	**100-200**	**0.5-1.3**	**0.2-0.6**	**0.5-0.8**
Hill's Prescription Diet r/d with Liver & Chicken Feline	114/5.5 oz.	3.1	9.2	15.4	37.5	31.3	512.5	746	108	1.67	0.29	0.62
Iams Veterinary Formula Weight Loss/Restricted-Calorie	172/6 oz.	4.3	15.5	1.7	44.2	32.3	na	na	na	na	0.43	0.86
Medi-Cal Calorie Control	99/165 g	na	26.0	1.3	49.6	na	na	na	na	na	1.9	1.6
Medi-Cal Fibre Formula	130/170 g	na	17.1	16.7	40.0	na	na	na	na	na	0.4	0.9
Medi-Cal Reducing Formula	111/170 g	na	27.2	1.3	54.3	na	na	na	na	na	1.0	1.6
Purina Veterinary Diets OM Overweight Management Feline Formula	150/5.5 oz.	3.9	14.6	10.2	44.6	23.2	na	na	na	na	0.31	0.99
Royal Canin Veterinary Diet Calorie Control CC High Fiber	164/6 oz.	4.1	21.3	7.7	33.5	32.5	na	276	na	0.43	0.38	0.81
Royal Canin Veterinary Diet Calorie Control CC High Protein	130/5.8 oz.	4.7	24.4	2.4	53.5	7.0	na	562	na	na	1.50	1.68

Key: ME = metabolizable energy, na = information not available from manufacturer, Fiber = crude fiber, Prot = protein, Carb = digestible carbohydrate, Carn = L-carnitine, Se = selenium, Na = sodium, P = phosphorus, g = grams.
*From manufacturers' published information or calculated from manufacturers' published as-fed values.
**Energy density values are listed on an as fed basis and are useful for determining the amount to feed; cup = 8-oz. measuring cup.
To convert to kJ, multiply kcal by 4.184.

CALCULATION BASED ON ESTIMATED IDEAL WEIGHT

A second method also depends on an estimate of the patient's ideal weight (**Table 27-12**) but requires a few simple calculations. Pets at ideal body weight in a thermoneutral environment will typically expend about 70% of their DER for maintenance of lean body tissue (RER). Maintaining adipose tissue in obese pets requires relatively little energy; therefore, most calories consumed by an overweight patient, regardless of the degree of obesity, are used to support lean body tissues. Although the lean body mass of an overweight patient is greater than the lean body mass of the same patient at its optimal weight, the relationship is not linear. This method, then, assumes the RER for the optimal weight and RER for obese

Table 27-9. Levels of key nutritional factors in selected commercial foods marketed for the metabolic approach to weight loss in cats compared to recommended levels.*

Dry foods	Energy density (kcal/cup)**	Carb (%)	Prot (%)	Fat (%)	Fiber (%)	Carn (ppm)	Vit E (IU/kg)	Vit C (mg/kg)	Se (mg/kg)	Na (%)	P (%)
Recommended levels	-	≤20	≥47-≤55	≤25	≥5	≥500	≥500	100-200	0.5-1.3	0.2-0.6	0.5-0.8
Hill's Prescription Diet m/d Feline	480	14.7	51.5	22.0	5.9	551.1	946	234	0.79	0.40	0.74
Purina Veterinary Diets DM Dietetic Management Formula	592	15.0	57.8	17.9	1.3	18.0	109	na	1.26	0.60	1.52

Moist foods	Energy density (kcal/can)**	Carb (%)	Prot (%)	Fat (%)	Fiber (%)	Carn (ppm)	Vit E (IU/kg)	Vit C (mg/kg)	Se (mg/kg)	Na (%)	P (%)
Recommended levels	-	≤20	≥47-≤55	≤25	≥5	≥500	≥500	100-200	0.5-1.3	0.2-0.6	0.5-0.8
Hill's Prescription Diet m/d Feline	156/5.5 oz.	15.7	52.8	19.4	6.0	524.2	810	125	1.77	0.36	0.69
Purina Veterinary Diets DM Dietetic Management Formula	194/5.5 oz.	8.1	56.9	23.8	3.7	na	214	na	na	0.39	1.10

Key: na = information not available from manufacturer, Carb = digestible carbohydrate, Prot = protein, Fiber = crude fiber, Carn = L-carnitine, Se = selenium, Na = sodium; P = phosphorus.
*From manufacturers' published information or calculated from manufacturers' published as-fed values; all values are on a dry matter basis unless otherwise stated.
**Energy density values are listed on an as fed basis and are useful for determining the amount to feed; cup = 8-oz. measuring cup. To convert to kJ, multiply kcal by 4.184.

Table 27-10. Selected commercial treats marketed for weight management in dogs and their respective levels of key nutritional factors (levels for maintenance of target weight (**Table 27-4**).*

	Energy per treat (kcal)	Energy density (kcal ME/g)	Fat (%)	Protein (%)	Fiber (%)	Phosphorus (%)	Sodium (%)
Recommended levels	na**	≤3.4	≤14	≥18	10-20	0.4-0.8	0.2-0.4
Hill's Prescription Diet Canine Treats	13	2.9	7.3	14.6	17	0.45	0.11
Royal Canin Veterinary Diet Canine Treats	14	3.4	6.3	10.9	6.8	0.47	0.19

Key: na = not applicable, ME = metabolizable energy.
*All values are on a dry matter basis except for energy (kcal)/treat, which is on an as fed basis.
**This information is for feeding purposes only. Treats should not make up more than 10% of the total caloric intake and these calories should be accounted for by reducing the amount of kcal fed as food, accordingly.

weight are similar enough to be representative of one another. If lean body mass is similar at ideal and obese body conditions, the energy required to maintain each body condition should also be similar; this assumption is the basis for this approach to calculating the initial food dosage for controlled weight loss. Because the lean body mass for a patient at its optimal weight will be less than when it is overweight, this method provides a more aggressive initial food dosage for weight loss than calculations based on the patient's obese weight. Also, as mentioned above, web-based programs exist for determining ideal or target weight of obese patients (**Box 27-10**).

For dogs and cats, use RER for optimal weight as an initial estimate of calories required for appropriate weight loss. RER can be obtained directly from **Table 27-3** or calculated as shown in **Table 27-13**. RER should provide approximately 70 to 80% of DER for optimal weight or 60 to 70% of DER for obese weight, assuming the animal is only 20% over optimal weight. This level of restriction should provide about 1 to 2% loss of obese body weight per week. Because this level of restriction will make caloric intake nearly equal to the calories required to support lean body mass at optimal weight, energy for physical activity must subsequently be supplied by further catabolizing fat stores. See **Box 27-8** for a discussion of exercise for weight loss.

After the caloric intake for weight loss is calculated, it is divided by the calorie content of the selected food to determine the actual daily amount to feed. **Table 27-12** provides an example of this method for calculating initial food dosage.

CALCULATION BASED ON CURRENT FOOD INTAKE

A third method requires knowledge of the number of calories the patient is currently eating based on information obtained from the patient history (**Box 27-1**) and feeding a reduced number of calories in the food form selected for weight loss. (See Assess and Select the Food section, above.) **Table 27-**

Box 27-10. Web-Based Programs for Obesity Management.

www.PetFit.com
This is a commercial pet food company sponsored free program for determining ideal (target) body weight for overweight/obese dogs and cats. The visuals in this program include a profile and dorsal view of a dog and cat with a slide bar beneath. The body condition score of the initial view is 3/5. The patient's current weight is entered and the slide bar is moved to the right (or left) to match the dimensions of the patient. After the operator is satisfied with the match, an ideal body weight is automatically calculated.

Balance IT (info@dvmconsulting.com)
Balance IT is a fee-based program designed to help veterinary health care teams with calculation-based weight-loss feeding plans. The user can select/enter all the foods a patient is currently fed (based on the diet history) and the program will then determine the caloric needs of the patient for weight loss. Users can set the desired weight-loss rates and select the commercial weight-loss food they wish to feed (along with any treats up to 10% of daily calories). The program calculates the amount to feed and enters this information into a report to be printed for clients. Based on weight rechecks, the software adjusts the amount to feed the patient.

Table 27-11. Methods for determining ideal/optimal body weight.

1. Consult the patient's medical record to determine if a body condition score (BCS) of 3/5 was recorded with a simultaneous ideal body weight.
2. Consult the patient's medical record to see if the patient's body weight was recorded at about the time the patient reached one year of age. Such a body weight would likely be near ideal (but not always). Thus, this method might not be as reliable as Method 1 above.
3. Consult **Table 27-3** in this text.
   a. Determine patient's current BCS and obtain current body weight.
   b. Locate the current BCS and body weight in **Table 27-3.**
   c. Note the weight in **Table 27-3** that coincides with a BCS of 3/5 in the same column.
4. Consult web-based programs (**Box-27-10**).

Table 27-12. Using ideal body weight to determine initial food dosage for controlled weight loss.

The following steps represent the process for estimating the initial amount to feed for weight loss using ideal body weight:
1. Determine the patient's current weight and BCS.
2. Consult **Table 27-3**; for current BCS, find current weight and read associated ideal weight (BCS 3/5) from same column.
3. Determine RER for ideal weight (also from **Table 27-3**, immediately below ideal weight) = initial estimated daily energy intake.
4. Divide RER by the as fed energy density of selected food = initial daily food dose.

An example case follows:
An obese dog weighs 30 kg and has a BCS of 5/5. Consulting **Table 27-3**, we determine that the dog's ideal body weight (BCS 3/5) is 22.5 kg. In **Table 27-3**, the RER for a 22.5-kg dog is located immediately below the weight. In this case it is 723 kcal/day.*
The food selected for weight loss provides 220 kcal/cup; 723 kcal/day ÷ 220 kcal/cup = 3.3 cups/day. This amount is a starting point and may need to be modified to achieve the desired weight loss.
Recheck body weight after two to three weeks. The weight-loss target should be between 0.5 and 2% per week of initial obese body weight.
Key: BCS = body condition score (Figures 1-2 and 1-3), RER = resting energy requirement.
*To convert to kJ, multiply kcal by 4.184.

14 provides more details and an example of this method. **Box 27-10** includes a web-based program that will perform calculations based on the current food information obtained from the diet history. This can be an excellent way to calculate the initial food dose if the recorded amount fed in the feeding history is complete and accurate. If the food history is incomplete, the owner can be instructed to return home and record actual amounts fed for a three-day period and either phone in the information or schedule a followup visit. Potential shortcomings of this approach include losing the attention and commitment of the owners due to busy schedules, inaccurate owner reports due to concerns of having been "feeding too much" and having to convert volume measures to calories if energy density on a volume basis is not readily available.

CALCULATION BASED ON OBESE WEIGHT

A fourth method for determining the amount to feed for controlled weight loss is based on obese weight, which is more straightforward to obtain than optimal weight. This method also includes a calculation for the amount of desired weekly weight loss.

With this method, the DER for obese weight is calculated. Then the caloric equivalent of adipose tissue to be lost per week is determined using a target of 1 to 2% of weight loss per week. This weekly amount of desired calorie deficit is converted to a daily amount and is subtracted from the previously calculated DER to provide the daily number of calories to feed for controlled weight loss. After the caloric intake for weight loss is calculated, it is divided by the calorie content of the selected food to determine the actual daily amount to feed. **Table 27-15** provides an example calculation using this method. Because the amount of lean body mass does not increase linearly with the degree of obesity, this method could overestimate the initial food dose for weight loss of very obese patients.

A reminder: all four methods generate what should be considered as starting points. Individual animals of the same weight have a wide variation of energy requirements (Figure 1-5). Thus, in actual practice, individual animals are encountered that need the same, markedly fewer and, occasionally, markedly more calories than product literature or calculations suggest. Caloric restriction may be insufficient to produce weight loss or may even produce weight gain in some patients (Laflamme et

Table 27-13. Two alternative methods for estimating resting energy requirement (RER).*

1) RER (kcal/day) = $70(BW_{kg})^{0.75}$. This calculation can be performed with a calculator that has a fractional exponent key or by cubing the body weight and taking its square root twice.
2) RER (kcal/day) = $30(BW_{kg}) + 70$. Results using this formula correlate well with results derived from Formula 1 above for body weights greater than 2 kg. Alternatively Table 5-2 provides this information for dogs weighing up to 70 kg.
*__Table 27-3__ provides RER estimates without requiring calculations.

Table 27-14. Using the food history to determine the initial food dosage for controlled weight loss.

The following steps represent the process for estimating the initial amount to feed for weight loss based on the amount of calories currently being fed to maintain the patient's obese weight.
1. Determine the food/treats currently being fed and, as close as possible, the exact amounts (volume and/or weight) being fed (**Box 27-1**).
2. Calculate the total calories currently being fed by obtaining calorie content information for the pet foods, treats and snacks from Chapters 13 (dogs) and 20 (cats) or product information; use Appendices 16 through 19 for the energy content of human food sources or consult product label information. This is done by multiplying the volume or weight of the food, treats and snacks by their caloric content and summing them. The sum is the calorie intake used to maintain the pet's current body weight.
3. Multiply the calorie sum obtained in Step 2 by 70% to obtain the initial number of calories to feed dogs and cats for controlled weight loss.
4. Convert the calorie target to a food dosage by dividing the calorie target by the energy density of the food selected for weight loss (kcal/cup for dry or kcal/can for moist). The answer will be the amount of food to feed per day.

An example case follows:
An obese dog weighs 30 kg and has a body condition score of 5/5.* According to the pet owner, the dog is fed only commercial food. The food history indicates the following daily intake: two cups of dry food (Brand A), one can (14.75 oz.) of moist food (Brand B) and four to five Brand C treats. Manufacturer's information regarding these foods indicates the following calorie content: 350 kcal/cup of dry food, 400 kcal/14.75-oz. can moist food, 50 kcal per treat. The total daily calorie intake is:
350 kcal/cup x two cups = 700 kcal**
+ 400 kcal/can x one can = 400 kcal
+ 5 treats x 50 kcal/treat = 250 kcal
Sum = 1,350 kcal/day

To determine the target number of calories to feed per day:
70% x 1,350 kcal = 945 kcal/day
To convert this to an amount of a selected weight-loss food to feed daily (in this case, the owner chose to feed a combination of moist (300 kcal/can) and dry (220 kcal/cup) weight-loss foods plus low-calorie treats (16 kcal/treat):
1 can x 300 kcal/can = 300 kcal
945 kcal weight-loss target – 300 kcal = 645 kcal left for dry food and treats
Feed 10 treats/day x 16 kcal/treat = 160 kcal
645 kcal – 160 kcal for treats = 485 kcal remaining for dry food
485 kcal ÷ 220 kcal/cup dry food = 2.2 cups dry food
Recheck body weight after two to three weeks to determine if adjustments need to be made.
Weight-loss target should be between 0.5 and 2% per week of initial obese body weight.
*(Figures 1-2 and 1-3)
**To convert to kJ, multiply kcal by 4.184.

Table 27-15. Using obese body weight and desired rate of weight loss to determine initial amount to feed for controlled weight loss.

The following steps represent the process for estimating the initial amount to feed for weight loss using obese body weight and a desired rate of weight loss:
1. Obtain current (obese) body weight.
2. Calculate DER for current body weight = estimated current daily energy intake.
3. Calculate the energy content of body fat (7,920 kcal/kg adipose tissue) to be lost weekly, assuming a target weight loss of between 0.5 to 2% initial body weight per week.
4. Divide the weekly amount of adipose calories by 7 to obtain desired daily calorie deficit.
5. Subtract the daily calorie deficit from the DER to obtain the number of calories to feed per day.
6. Divide the number of calories to feed per day by the energy density of the selected food to determine the amount of food to feed per day.

An example case follows:
An obese dog has a body weight of 30 kg and a BCS of 5/5. The DER for the dog's obese weight is calculated using the formula DER = RER x 1.4. RER (kcal/day) = $30(BW_{kg}) + 70$. RER = 30(30 kg) + 70 = 970 kcal/day. DER = 1.4 x RER = 1.4 x 970 = 1,358 kcal/day. RER can also be obtained directly from **Table 27-3**.
A targeted weight loss of 1.5% of the dog's obese weight per week would be 0.45 kg/week.
The energy density of adipose tissue is 7,920 kcal/kg; 7,920 kcal/kg x 0.45 kg = 3,564 kcal/week or 509 kcal/day (3,564 kcal/week ÷ 7 days/week).
The calculated daily energy intake for this rate of weight loss = 1,358 kcal/day – 509 kcal = 849 kcal/day.
The food selected for weight loss provides 220 kcal/cup; 849 kcal/day ÷ 220 kcal/cup = 3 and 7/8 cups/day. This amount is a starting point and may need to be modified to achieve the desired weight loss. Recheck body weight after two to three weeks.
Key: DER = daily energy requirement, BCS = body condition score (Figures 1-2 and 1-3), RER = resting energy requirement, BW = body weight.

al, 1997). Patients will need to be rechecked regularly, initially every two to three weeks, so that modifications, if necessary, can be made to their food intake (Saker and Remillard, 2005). **Figure 27-1** is an algorithm for monitoring progression of weight loss and making decisions to keep weight loss progressing toward the target (ideal) weight. The pet owner's clear understanding that the initial amount to feed might need revision is more important than whether the veterinarian's initial recommendation is correct. Continually managing the client's expectations is very important.

Finally, a cautionary reminder about food restriction in cats: restricting calories for DER at optimal weight of a cat by more than 70% effectively makes caloric intake less than RER because DER for neutered adult cats is only 1.2 to 1.4 x RER. RER represents a theoretical minimum for daily energy consumption for cats because of the risk for hepatic lipidosis (Biourge et al, 1994). However, experimental and clinical trials using caloric restrictions between 59 and 80% of RER produced acceptable rates of weight loss in overweight cats with no biochemical evidence of hepatic lipido-

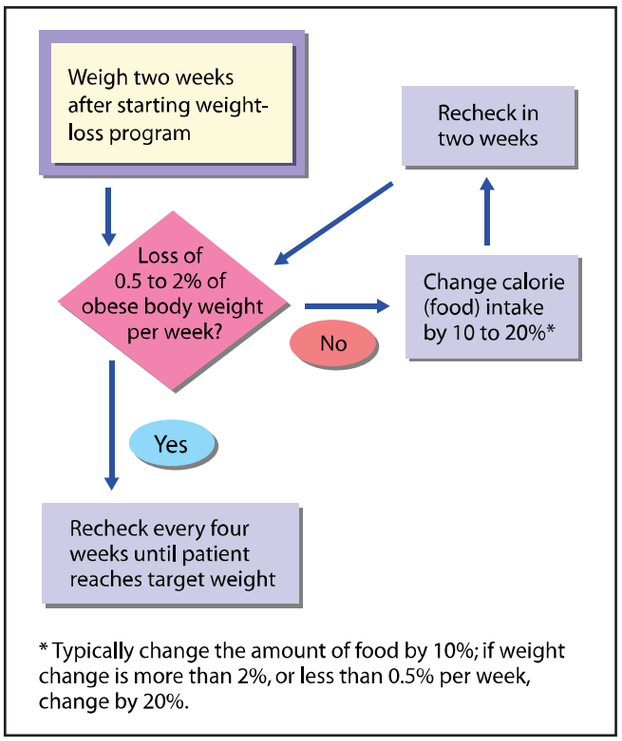


Figure 27-1. Algorithm for decision making and patient monitoring during weight loss.

Figure 27-2. A commercial feeding system for cats and small dogs. Close proximity of a special collar unlocks the feeder door and the pet wearing the collar simply pushes the door open and enters the feeder. More than one pet can have access to one feeder. (Courtesy of NekoFeeder, LLC. www.nekofeeder.com [802-264-6055] 6D Laurette Drive, Essex Junction, VT.)

sis (Markwell et al, 1996). Thus, when feeding obese cats for weight loss, be sure they are eating at least 50% of their estimated food dose to prevent development of hepatic lipidosis. A weight loss goal of 0.5 to 1% per week is safer.

Feeding Methods for Weight Reduction

Consideration should be given to how the owner feeds the pet. Feeding foods free choice may work for individual cats and dogs that can self-regulate their daily intake of food to match their DER. However, free-choice feeding rarely works for weight loss or for maintenance of reduced body weight even with the most calorie-restricted foods.

Dogs and cats on weight-reduction programs should be fed multiple small meals during the day rather than a single large meal to take advantage of the obligatory energy cost for digesting and absorbing food. The optimal number of meals for maximizing caloric expenditure from TEF has not been determined. However, the total daily food should be divided into at least two portions fed eight to 12 hours apart. Most pet owners can feed two meals per day without disrupting their schedules. Clients who can conveniently feed three or more meals per day should do so.

Meal sizes should be in portions that are practical to measure (i.e., to the nearest one-fourth cup or can). If the daily amount of food does not divide evenly into portions that are readily measurable, some meals will contain less and others more food. The meals containing more food should be fed when the owner will be with the pet for the longest time between meals. The pet should be kept out of the kitchen and dining areas during preparation and consumption of family meals. These practices can help reduce the pet's begging and the owner's urge to give the pet additional food or treats.

As with any food change, it is best to transition the patient to the new weight-loss food gradually over a period of several days (Table 1-1).

In multi-pet households, care must be taken to ensure that obese patients being treated for weight loss do not have access to other pets' food. This can be challenging. Commercial feeders are available for pets that limit access to food. Internet searches can be conducted to locate sources of commercial automatic feeders that might make it easier to feed an individual dog or cat for weight loss in a multi-pet household. **Figure 27-2** shows an example of a commercial feeder for cats and small dogs that selectively restricts access to food. Also, feeders for cats in multi-cat households can be constructed from a cardboard box. The box should be of sufficient size for one cat and its bowl of food. An opening small enough to allow a thin cat, but not the overweight cat, to enter and exit is cut into the closed box. The food intended for the thinner

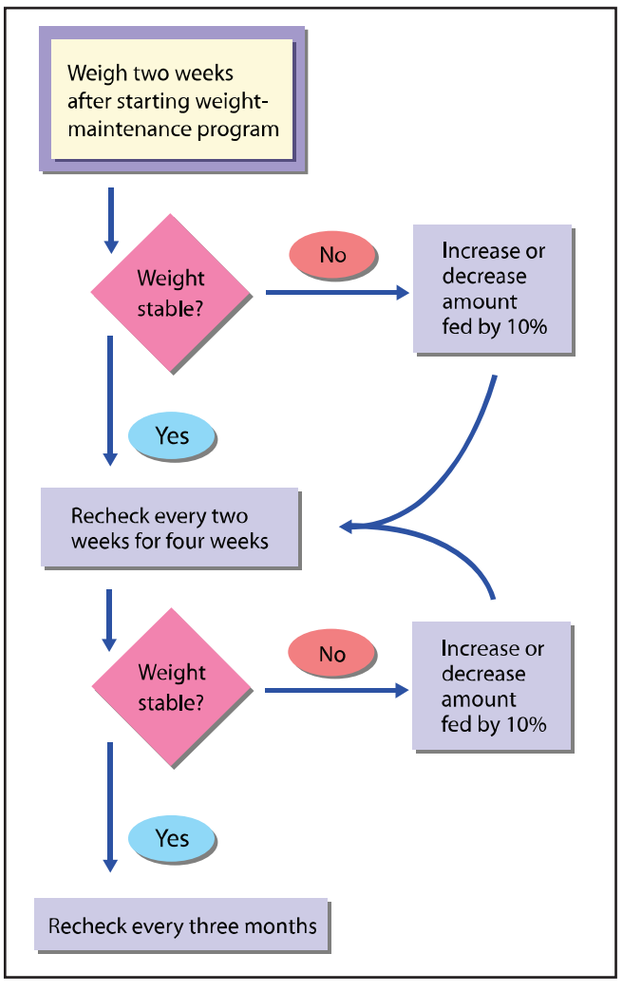


Figure 27-3. Algorithm for stabilizing body weight after weight loss.

cat is placed in the box, limiting access by the overweight cat. However, industrious overweight cats sometimes defeat such a system.

REASSESSMENT

Assess the Performance of the Weight-Loss Program

Regular monitoring of patient weight loss is important to ensure the prescribed program is effective and to motivate the owner. Simply telling a patient's owner to feed a certain quantity of a calorie-restricted food and increase the patient's activity is unlikely to produce weight loss for several reasons. Office rechecks or "weigh-ins" to monitor patient progress throughout weight loss are an integral component of a weight-reduction program, equal in importance to diet and exercise (**Box 27-11**). There are three critical times during a weight-reduction program when rechecks can prevent the program from failing. These are at the very beginning, the very end and anytime in between when weight loss slows or stops (**Figure 27-1**).

The focus should be on acceptable rates of weight loss instead of calculating a specific number of days that pet owners view as the time it will take to complete the weight-loss program. It can be disheartening to pet owners and harmful to the veterinarian's credibility, and thus the weight-loss program, if a single specific time is projected for returning the animal to optimal weight and then, as in most cases, it actually takes more time. The minimum and maximum acceptable times for a cat or dog to complete a weight-loss program can be calculated (**Box 27-12**). Realistically, eight to 12 months will be required to complete the weight reduction of most dogs and cats that are truly obese and that have metabolic rates lower than predicted by standard equations; some will take even take longer.

If weight loss is not proceeding at a rate between 0.5 to 2% per week, decrease the amount being fed by 10 to 20% and recheck body weight in two weeks. Continue this cycle until the desired rate of weight loss is obtained. After the desired rate is obtained, continue feeding that amount of food until the target weight is obtained, rechecking progress every four to six weeks.

Adjunctive Therapy

Box 27-13 reviews a new drug that may help manage overweight and obese conditions in dogs and cats.

FEEDING PLANS FOR WEIGHT MAINTENANCE

After the patient reaches the target weight, a weight-maintenance program should be initiated to ensure that the target weight is maintained and weight regain does not occur. The success of the weight-maintenance program, like that of the weight-loss program, depends on continued pet owner commitment (**Box 27-7**), proper food and feeding plan, exercise (**Box 27-8**), pet owner communication (**Box 27-9**) and patient monitoring (reassessment). These patients, like human patients, are at considerable risk for weight regain and resumption of their previous overweight condition.

Assess and Select the Food for Weight Maintenance

Simply feeding the animal its previous food, even at reduced amounts, may lead to weight regain, negating the effort required to produce weight loss and the resulting benefits. Thus, the strategy of energy restriction is also used to avoid weight regain. The same nutritional principles discussed for weight loss are employed, but energy is less restricted. **Tables 27-16** for dogs and **27-17** for cats compare the key nutritional factor targets to the key nutritional factor content of selected commercial veterinary therapeutic foods marketed for maintenance of target weight after weight loss or prevention of weight gain in patients not previously overweight. Select the food that

Box 27-11. Rechecks and the Overall Success of a Weight-Loss Program.

Rechecks accomplish several things necessary to ensure success of a weight-loss program. When done timely and properly, rechecks improve compliance and ensure the program is conducted efficiently and effectively. Rechecks reinforce the commitment of owners and the veterinary health care team in helping patients lose weight. Also, rechecks give pet owners an opportunity to see the results of their efforts or, on the contrary, to see the impact of inadvertently or purposefully feeding extra calories or not ensuring that the pet performed the specified amount of exercise since the last recheck.

During rechecks, the veterinary health care team can adjust the caloric intake, feeding plan and exercise recommendations to get or keep weight loss proceeding at a desirable rate. The opportunity to make these adjustments is a key iterative step in a weight-loss program. The initial considerations and calculations for caloric restriction and the feeding plan, no matter how carefully or scientifically made, are only an educated guess at what the caloric restriction should be for a safe and reasonable rate of weight loss for an individual patient. The appropriateness of this educated guess is ultimately determined by changes in the body weight and body condition score. Pelvic and abdominal girth measurements, determined with a tape measure, can also be used to track progress.

Pet owners need reinforcement in the form of compliments and encouragement even when their overweight pets lose weight. Such pet owners are likely to be experiencing one or more negative consequences as a result of changing what and how they feed their pet. The dog or cat can manifest hunger. As a result, some pet owners will feel they are depriving their pet of needed food or affection. The pet owner's resistance to acquiescing to the pet's behavior and the urge to feed the pet more food should be acknowledged and reinforced.

Reinforcement and encouragement are certainly required when weight remains the same, or worse, increases from one recheck to the next. The reason for lack of progress needs to be determined and explained. Sometimes the animal is actually losing weight and it is simply not detected, either because the scale is not sensitive enough or the gastrointestinal or urinary tract has above average contents at the time of the weighing. If this is the case, the weight is likely to be decreased at the next recheck. A true lack of progress can be due to consumption of additional food, either because the patient had unlimited access to food while unsupervised, or the owners fed more treats or snacks than recommended. Insufficient exercise will also slow, or stop, weight loss. In any of these cases, owners need to understand what caused the observed results and efforts should be redoubled to assist the patient and the owner in adhering to the feeding and exercise plan.

However, insufficient weight loss could occur despite what any calculation would suggest and despite 100% compliance by the owner. Problems with caloric restriction can occur initially or after some period of weight loss, perhaps because of a decreasing metabolic rate from the weight loss. If monitoring and counseling in the form of rechecks are not being done, these problems will not be detected until the patient is seen some time in the future weighing the same or more than when the weight-loss program was started. The opportunity to promote weight loss in such patients will probably be lost because the pet owner will conclude that switching the food and tolerating undesirable behaviors did not produce results and was not worth the trouble and/or expense involved.

The best reinforcement and encouragement come initially from seeing the pet's body weight decrease, and later from seeing the return of normal body contours and resolution of clinical signs (e.g., better exercise tolerance, reduced lameness or decreased insulin doses). However, if the period of time between rechecks is short, or the rate of weight loss is particularly slow, progress based on body weight alone may not be readily apparent.

When dogs and cats lose or gain weight, the body dimension that changes most is the abdominal (pelvic) circumference. The thoracic circumference will also change somewhat, but the magnitude will not be as great or the change as readily measurable as in the pelvic region. If progress is slow, sometimes the pelvic circumference will decrease between rechecks even when body weight remains constant or vice versa. The decrease in circumference indicates progress and does not need to be converted into a decrease in body fat to be interpreted. In fact, simply measuring pelvic and thoracic circumferences at each recheck and periodically reevaluating the patient's body condition score could track progression of weight loss. These methods of assessing weight loss should be considered in settings such as house-call practices where veterinarians may not have scales capable of measuring the change in a pet's body weight.

Rechecks should be scheduled to allow enough time for detectable progress, but not so much time that the pet owner becomes dismayed at the lack of progress when problems are finally detected. Shorter intervals between rechecks are needed at the beginning and end of a weight-reduction program when the caloric content and amounts of food are changed. Initially two weeks is a reasonable recheck interval for most patients. Cats and some small dogs may take three weeks to lose enough weight for scales to measure the loss. At the most, no more than four weeks should pass before the patient is rechecked. However, four weeks may be too long for some patients if changes need to be made to the feeding or exercise plans.

Ideally, three body weights would be used to establish a true trend for, and an accurate rate of, weight loss. Thus, a determination that initial caloric restriction is insufficient to produce weight loss can be made sooner with a two-week recheck interval than with a four-week interval, saving at least two and perhaps six weeks, during which the animal is not losing weight. Intervals between rechecks can be increased to every four weeks after weight loss is documented to occur at a steady rate acceptable to the pet owner and veterinary health care team. If the animal fails to lose weight during a four-week interval with no apparent explanation (i.e., more calories or less exercise) then the rechecks need to be more frequent to determine if weight loss has stopped and to assess the degree of caloric restriction needed for weight loss to recur (**Figure 27-3**).

Box 27-12. Calculating Time for Weight Loss and its Use in Monitoring Patients.

The loss of 2% of initial body weight per week can be used as the maximum desired rate of weight loss in typical obese patients and a loss of 0.5% of initial body weight per week can be used as the minimum desired rate of weight loss. These two weight-loss rates can be used to calculate the minimum and maximum time expected for a dog or cat to reach its ideal or target body weight. The following case will demonstrate a simple method for determining this time interval and show its use in monitoring response to therapy in an obese cat.

METHOD

Obese weight – desired weight = A (kg)
Obese weight x 2% = B (kg/week)
A ÷ B = C (number of weeks necessary for weight loss at 2% rate)
C x 4 = D (number of weeks necessary for weight loss at 0.5% rate)
Desired weight loss should occur within these two time frames.

CASE

Patient Assessment

A three-year-old, neutered female domestic shorthair cat weighing 5.9 kg is presented for annual vaccinations. The owner had recently acquired the cat from her parents and was concerned that the cat was overweight compared with a cat owned by her roommate. All physical examination findings were normal except for obesity. Results of a complete blood count, serum biochemistry profile and urinalysis were normal.

The cat's body condition was assessed as 4.5/5. Ideal body weight was estimated to be 4.5 kg (**Table 27-3**).

Assess the Food and Feeding Method

The cat was fed one-half cup of a dry specialty brand cat food and 3 oz. of various brands and flavors of moist cat foods once daily. The cat consumed at least 400 kcal (1,674 kJ) of metabolizable energy (ME) daily.

Feeding Plan

The resting energy requirement (RER) at the estimated optimal body weight was calculated as follows: RER optimal weight = $70(4.5)^{0.75}$ = 218 kcal ME (912 kJ). Daily energy requirement (DER) would be approximately 1.4 x RER or 305 kcal ME (1,276 kJ). The daily caloric intake was much higher than the estimated DER.

The initial caloric restriction was set at RER calculated for optimal body weight. The owner was also instructed to increase the cat's activity as much as possible. The food was changed to commercial products containing less fat and more fiber. The owner was asked to return every two weeks for the first two months to monitor progress.

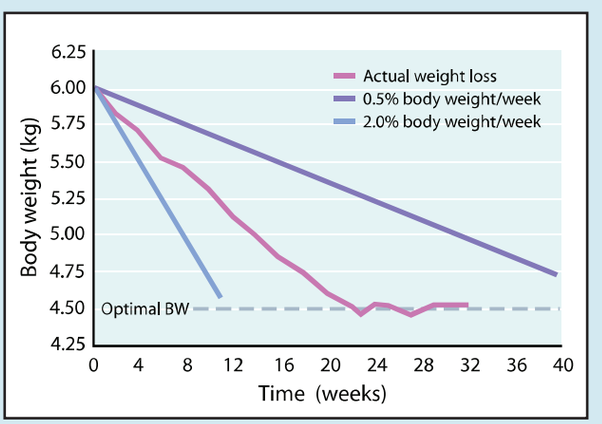
Calculations for Weight Loss

Obese weight = 5.9 kg
Desired weight = 4.5 kg
Desired weight loss = 1.4 kg

5.9 x 2% = 0.12 kg/week
1.4 kg ÷ 0.12 = 12 weeks at 2% rate
12 weeks x 4 = 48 weeks at 0.5% rate

Reassess

The accompanying figure shows the weight loss that occurred with this feeding plan and exercise. The actual body weight loss for this cat falls nicely within the calculated minimum and maximum rates. The feeding plan was changed at 22 weeks to stabilize the body weight at 4.5 kg.



is most similar to the key nutritional factor targets for managing weight maintenance in dogs or cats.

If a metabolic weight-control food was used for an overweight feline patient, it is also appropriate to switch to a calorie-restricted food for maintenance of the target weight, after the target weight has been achieved.

If the owner intends to feed treats or snacks, the same treats (**Table 27-10**) and snacks (the dry form of the weight-maintenance food, popcorn (air popped), low-fat, low-starch vegetables) recommended for weight loss can be considered for use in the weight-maintenance program. As with the weight-loss program, the calories supplied by the treats must be accounted for within the total calories allowed in the feeding plan.

Assess and Determine the Feeding Method for Weight Maintenance

Feeding method considerations include determining the amount of food to feed for weight maintenance and selecting the way the food is to be fed.

How to Estimate the Amount of Food to Feed for Weight Maintenance

The following methods for determining the amount to feed for maintenance of target weight after weight loss provide best estimates. Patients should initially receive frequent rechecks (every one to two weeks for four to six weeks) (**Figure 27-3**) to guard against weight regain.

Box 27-13. Pharmacologic Approach to Obesity in Dogs: Dirlotapide.

Given the growing health problem of obesity in people, dogs and cats, pharmacologic investigations to manage obesity have been underway for many years. There are numerous receptors in the hypothalamus that have been identified as possible targets of a pharmacologic remedy to obesity. Hypothalamic receptors appear to be reasonable targets given the role of the hypothalamus in controlling appetite, food intake and energy expenditure.

During dietary fat digestion and absorption, lipids enter an enterocyte and are repackaged as chylomicrons by a microsomal triacylglycerol transfer protein (MTP). From there they are transferred to the lymphatics and blood. Dirlotapide[a] is a MTP inhibitor that is highly selective for enterocytes when taken orally. Dirlotapide partially inhibits MTP resulting in an accumulation of lipid within the mucosal cell lining. Triglyceride accumulation within enterocytes triggers secretion of hypothalamic satiety hormones (PYY and GLP-1), which ultimately leads to a voluntary decrease of food and calorie intake. The dirlotapide label insert states that the "...mechanism for producing weight loss is not completely understood, but seems to result from reduced fat absorption and a satiety signal from lipid-filled cells lining the intestine." It has been estimated that 90% of the weight lost is due to decreased food intake and 10% is due to reduced lipid absorption. Fecal fat increases in dogs given dirlotapide because enterocytes containing fat are normally shed as part of fecal material.

Weight-loss programs that incorporate MTP inhibitors will almost certainly be successful initially and may help dogs with immediate medical concerns related to excessive weight. But it is imperative that weight-loss programs incorporating MTP inhibitors take advantage of this initial short-term success and capitalize on the opportunity to change owner behaviors, which will then foster long-term success. If this opportunity is not captured, weight gain (rebound) will be inevitable when the MTP inhibitors are withdrawn because appetite returns within days of discontinuing the drug. If used incorrectly, and not integrated into an overall plan of proper food, food dosage and exercise, weight loss with MTP inhibitors will be cyclic and results will be just as frustrating as current programs.

ENDNOTE

a. Slentrol. Pfizer Animal Health, New York, NY, USA.

The Bibliography for **Box 27-13** can be found at www.markmorris.org.

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Table 27-16. Levels of key nutritional factors in selected commercial foods marketed for weight maintenance in dogs after a weight-loss program compared to recommended levels.*

Dry foods	**Energy density (kcal/cup)****	**Energy density (kcal ME/g)**	**Fat (%)**	**Fiber (%)**	**Prot (%)**	**Carb (%)**	**Carn (ppm)**	**Vit E (IU/kg)**	**Vit C (mg/kg)**	**Se (mg/kg)**	**Na (%)**	**P (%)**
Recommended levels	**-**	**≤3.4**	**≤14**	**10-20**	**≥18**	**≤55**	**≥300**	**≥400**	**≥100**	**0.5-1.3**	**0.2-0.4**	**0.4-0.8**
Hill's Prescription Diet w/d Canine	243	3.3	8.8	16.4	18.9	51.2	349.5	574	274	1.34	0.22	0.56
Hill's Prescription Diet w/d with Chicken Canine	239	3.2	8.7	17.1	19.1	50.1	328.0	611	298	1.52	0.27	0.56
Iams Veterinary Formula Weight Control D/ Optimum Weight Control	209	3.5	9.5	3.0	28.7	51.2	na	na	na	na	0.51	1.00
Medi-Cal Weight Control/ Mature	320	na	8.5	4.0	19.5	na	na	na	na	na	0.2	0.8
Purina Veterinary Diets OM Overweight Management	266	3.0	7.2	10.3	31.1	44.2	na	na	na	na	0.31	0.89
Moist foods	**Energy density (kcal/can)****	**Energy density (kcal ME/g)**	**Fat (%)**	**Fiber (%)**	**Prot (%)**	**Carb (%)**	**Carn (ppm)**	**Vit E (IU/kg)**	**Vit C (mg/kg)**	**Se (mg/kg)**	**Na (%)**	**P (%)**
Recommended levels	**-**	**≤3.4**	**≤14**	**10-20**	**≥18**	**≤55**	**≥300**	**≥400**	**≥100**	**0.5-1.3**	**0.2-0.4**	**0.4-0.8**
Hill's Prescription Diet w/d Canine	329/13 oz.	3.5	12.7	12.4	17.9	52.6	364.1	614	116	0.72	0.24	0.52
Medi-Cal Weight Control/ Mature	370/396 g	na	10.0	5.5	21.5	na	na	na	na	na	0.3	0.6
Purina Veterinary Diets OM Overweight Management	189/12.5 oz.	2.5	8.4	19.2	44.1	21.7	na	na	na	na	0.28	1.06

Key: ME = metabolizable energy, na = information not available from manufacturer, Fiber = crude fiber, Prot = protein, Carb = digestible carbohydrate, Carn = L-carnitine, Se = selenium, Na = sodium, P = phosphorus, g = grams.
*From manufacturers' published information or calculated from manufacturers' published as-fed values. All values are on a dry matter basis unless otherwise stated.
**Energy density values are listed on an as fed basis and are useful for determining the amount to feed; cup = 8-oz. measuring cup.
To convert to kJ, multiply kcal by 4.184.

Table 27-17. Levels of key nutrients in selected commercial foods marketed for weight maintenance in cats after a weight-loss program compared to recommended levels.*

Dry foods	Energy density (kcal/cup)**	Energy density (kcal ME/g)	Fat (%)	Fiber (%)	Prot (%)	Carb (%)	Carn (ppm)	Vit E (IU/kg)	Vit C (mg/kg)	Se (mg/kg)	Na (%)	P (%)
Recommended levels	-	≤3.8	≤18	6-15	≥35	≤40	≥500	≥500	100-200	0.5-1.3	0.2-0.6	0.5-0.8
Hill's Prescription Diet w/d Feline	281	3.5	9.8	7.6	39.0	37.4	498.9	692	117	0.85	0.30	0.77
Hill's Prescription Diet w/d with Chicken Feline	278	3.5	9.9	7.6	39.9	35.4	500	721	122	0.70	0.35	0.86
Iams Veterinary Formula Weight Control D/ Optimum Weight Control	326	3.8	12.2	1.5	38.6	41.2	na	na	na	na	0.39	1.01
Medi-Cal Weight Control	325	na	11.8	3.4	34.4	na	na	na	na	na	0.3	1.0
Purina Veterinary Diets OM Overweight Management Feline Formula	321	3.6	8.5	5.6	56.2	22.4	na	693	116	na	0.57	1.19
Moist foods	**Energy density (kcal/can)****	**Energy density (kcal ME/g)**	**Fat (%)**	**Fiber (%)**	**Prot (%)**	**Carb (%)**	**Carn (ppm)**	**Vit E (IU/kg)**	**Vit C (mg/kg)**	**Se (mg/kg)**	**Na (%)**	**P (%)**
Recommended levels	-	≤3.8	≤18	6-15	≥35	≤40	≥500	≥500	100-200	0.5-1.3	0.2-0.6	0.5-0.8
Hill's Prescription Diet w/d with Chicken Feline	127/5.5 oz.	3.5	16.6	10.6	39.6	26.4	514.9	745	115	1.70	0.38	0.68
Medi-Cal Weight Control	144/170 g	na	22.6	4.2	40.0	na	na	na	na	na	0.5	1.1
Purina Veterinary Diets OM Overweight Management Feline Formula	150/5.5 oz.	3.9	14.6	10.2	44.6	23.2	na	na	na	na	0.31	0.99

Key: ME = metabolizable energy, na = information not available from manufacturer, Fiber = crude fiber, Prot = protein, Carb = digestible carbohydrate, Carn = L-carnitine, Se = selenium, Na = sodium, P = phosphorus, g = grams.
*From manufacturers' published information or calculated from manufacturers' published as-fed values. All values are on a dry matter basis unless otherwise stated.
**Energy density values are listed on an as fed basis and are useful for determining the amount to feed; cup = 8-oz. measuring cup. To convert to kJ, multiply kcal by 4.184.

For both dogs and cats, the simplest method for determining the amount to feed for weight maintenance is to obtain the food dose recommendation from the company providing the food. As with foods intended for weight loss, this information may be available on the product label, from product literature, from the company website or by using specially designed "calculators" or proprietary software programs (**Box 27-10**). The last method should only be considered if the amount fed for weight loss was determined this way and was appropriate (i.e., successful) for weight loss.

A more reliable, safer method is to feed 10% more calories than were required for weight loss. After the initial caloric intake for weight maintenance is calculated, divide it by the calorie content of the selected food to determine the actual daily amount to feed. **Table 27-18** provides an example of this method for calculating initial food dosage. Rechecks and adjustments will likely need to be made. (See Reassessment.)

How the Food is Fed

Free-choice feeding is a risk factor for becoming overweight. As with weight-loss programs, free-choice feeding rarely works for maintenance of reduced body weight even with the most calorie-restricted foods. Thus, as with the weight-loss program, patients being fed to maintain their target weight should be fed multiple small meals during the day to take advantage of the obligatory energy cost for digesting and absorbing food. The total daily food should be divided into at least two portions fed eight to 12 hours apart. Most pet owners can feed two meals per day without disrupting their schedules. Clients who can conveniently feed three or more meals per day should do so.

Meal sizes should be in portions that are practical to measure (i.e., to the nearest one-fourth cup or can). If the daily amount of food does not divide evenly into portions that are readily measurable, some meals will contain less and others more food. The meals containing more food should be fed when the owner will be with the pet for the longest time between meals. As with the weight-loss program, the patient should be kept out of the kitchen and dining areas during preparation and consumption of family meals. These practices can help reduce the pet's begging and the owner's urge to give the pet additional food or treats.

As with any food change, it is best to transition the patient to the new weight-maintenance food gradually over a period of a few days (Table 1-1).

REASSESSMENT

Assess the Performance of the Weight-Maintenance Program

Figure 27-3 is a simple algorithm that outlines the reassessment process for weight maintenance after successful weight

Table 27-18. Using number of calories fed for weight loss to determine the initial amount of food to feed for target weight maintenance.

The amount of food fed for weight loss at the time the target weight was achieved is the basis for a method of determining the amount of food to feed initially to avoid weight regain. The following steps are involved in this process:

1. First, the daily number of calories fed for weight loss is calculated by multiplying the amount of the weight-loss food fed (usually a volume measure) by its caloric density. Caloric density can be obtained from **Tables 27-16** (dogs) or **27-17** (cats) or from product information.
2. Next, increase the number of calories by 10% to determine the estimated daily number of calories to feed (initially at least) to maintain the target weight.
3. Finally, divide the daily number of calories by the energy density of the food selected for weight maintenance to determine the amount of this food to feed per day.

An example case follows:
Through a well-executed weight-loss program, a previously obese dog achieved the target weight of 25 kg. It was being fed 3.5 cups of an appropriate energy-restricted food formulated for weight loss. The energy density of the weight-loss food is 220 kcal/cup. The amount of food fed is multiplied by the energy density of the food (3.5 cups x 220 kcal/cup) to yield approximately 770 kcal/day.*
The daily number of calories fed for weight loss is increased by 10% (10% x 770 kcal = 77 kcal; 770 kcal + 77 kcal = 847 kcal) to yield the number of calories to feed as a starting point for weight maintenance.
The selected weight-maintenance food provides 243 kcal/cup (obtained from product information). The daily calories for weight maintenance are divided by the energy density of the weight-maintenance food to yield the daily amount to feed (847 kcal/day ÷ 243 kcal/cup = 3.5 cups/day).
Note that this is the same volume of food that was being fed for weight loss. This is because the weight-maintenance food contains 10% more calories/cup than the weight-loss food.
This calculation assumes that if treats were fed during the weight-loss program that the same amount or fewer are fed during the weight-maintenance program. The same is true for the amount of exercise.
At least three days should be spent transitioning to the new food. Body weight should be rechecked every week or two for four to six weeks. Adjustments in increments of 10% should be made until body weight stabilizes at the target weight.
*To convert to kJ, multiply kcal by 4.184.

loss. Rechecks are essential after the pet attains its target weight. More frequent rechecks are needed when the animal reaches its target weight and calories are increased to maintain that weight. Rechecks should occur every two weeks to assess the appropriateness of caloric intake in conjunction with continued exercise. During this stage of the weight-maintenance program, no more than two weeks should elapse between weigh-ins because weight regain can rapidly occur. If changes in food intake are necessary to maintain the target weight, increase or decrease the amount in 10% increments; be careful not to allow weight regain.

Maintain the every two-week recheck schedule until the patient's body weight has stabilized at the desired weight for at least three consecutive weighins. Then, rechecks can occur every three months for a year and finally to six months thereafter. The precise timing of the rechecks isn't as important as the general notion of the timely tracking of the patient's body weight and adjusting the amount of food to feed, as necessary. Such rechecks also help reinforce compliance as with the weight-loss program (**Box 27-11**).

ACKNOWLEDGMENT

The authors and editors thank Dr. William J. Burkholder for his contribution to this chapter in the previous edition.

ENDNOTE

a. Schoenherr WD. Hill's Science and Technology Center, Topeka, KS, USA. Unpublished data. 2003.

REFERENCES

The references for **Chapter 27** can be found at www.markmorris.org.

CASE 27-1

Respiratory Distress in an Obese Miniature Poodle

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Patient Assessment

A four-year-old intact male miniature poodle weighing 17.3 kg was admitted for coughing, dyspnea, cyanosis and exercise intolerance. Physical examination findings were normal except for obesity. Results of a complete blood count, serum biochemistry profile, urinalysis, thoracic radiography and fluoroscopic examination of the trachea were normal. Bronchoscopy revealed no abnormalities. Cultures of tracheal and bronchial washings were negative for growth of pathogenic organisms. Lung scintigraphy showed no pulmonary vascular deficits.

Body condition score was 5/5. Morphometric measures estimated 47% of the dog's weight was fat. Optimal body weight was estimated to be 9.1 kg, making the patient's initial body weight 90% above optimal.

Assess the Food and Feeding Method

Table 1 lists the dietary history.

Questions

1. Estimate the amount of energy consumed by this patient each day.
2. Calculate the daily energy requirement (DER) for this patient at its estimated optimal body weight and compare this number with the energy estimate in Question 1.
3. Outline a feeding, exercise and monitoring plan for weight reduction for this dog.

Answers and Discussion

1. The energy consumed by the dog each day is at least 1,247 kcal (5.22 MJ). This is estimated from the moist food (one can, 556 kcal/can [2.33 MJ/can]), dry food (one cup, 327 kcal/cup [1.37 MJ/cup]), commercial treats (five treats, 20 kcal/treat [84 kJ/treat]) and ice cream (one cup, 264 kcal/cup [1.11 MJ/cup]). The daily caloric consumption was probably higher because the dog also ate various meats from the owner's meals.
2. The resting energy requirement (RER) at the estimated optimal body weight is calculated as follows: RER optimal weight = $70(9.1)^{0.75}$ = 367 kcal (1.54 MJ). DER would be approximately 1.4 to 1.6 x RER or 514 to 587 kcal (2.15 to 2.46 MJ). The daily caloric intake estimated in Question 1 is much higher than the estimated DER (about double).
3. The initial caloric restriction was set at an amount slightly above RER calculated for optimal body weight. The owners were instructed to feed no ice cream, meat or other table foods. The commercial treats were continued but fewer were given per day. The food was changed to a commercial product containing less fat and more crude fiber. Caloric restriction was accomplished using the specific foods and feeding methods listed in **Table 2**.

   The owners were also instructed to walk the dog on a leash daily. Initially they were to walk only as far as the dog could tolerate without becoming dyspneic. The walks were gradually increased to 20 to 30 minutes per walk, once or twice a day. The owners were asked to return every two weeks for the first couple of months to weigh the dog and monitor progress.

Progress Notes

Figure 1 shows the weight loss that occurred with this feeding plan and exercise. The coughing and dyspnea gradually resolved after the dog lost approximately 2 kg. The owners noticed a dramatic increase in the dog's activity after three months. The food was changed on Week 34 of the weight-reduction program to the foods and feeding methods listed in **Table 3**. Body weight stabilized (**Figure 1**) and the dog remained free of respiratory signs and distress.

Animals that are obese because of gross overfeeding are the

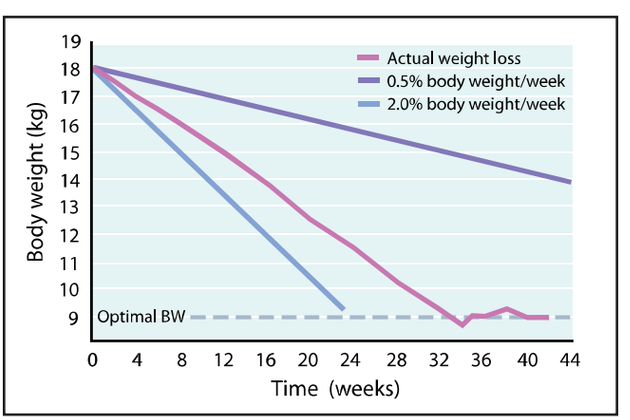

Figure 1. Progression of body weight loss compared with the minimum (loss of 0.5% of initial body weight/week) and maximum (loss of 2% of initial body weight/week) rates of weight loss.

patients most likely to achieve expected rates of weight loss when owners comply with caloric restriction.

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Endnotes

a. Hill's Pet Nutrition, Inc., Topeka, KS, USA. Science Diet Canine Maintenance, moist and Science Diet Canine Maintenance, dry are currently marketed as Science Diet Beef & Chicken Entrée Adult Canine and Science Diet Adult Original Formula. Science Diet Canine Maintenance Light, dry is currently marketed as Science Diet Light Adult Canine.
b. Nabisco, East Hanover, NJ, USA.

Table 1. Foods and feeding method assessment of an obese miniature poodle with respiratory distress.

Foods	Feeding method
Science Diet Canine Maintenance, moist[a]	One can, once daily
Science Diet Canine Maintenance, dry[a]	One cup, once daily
Milk-Bone treats (small)[b]	Five, daily
Ice cream	One cup, once daily
Various meats from owner's meals	Once or twice daily

Table 2. Feeding plan for weight reduction.

Foods	Feeding method	kcal (kJ)
Prescription Diet r/d Canine, moist[a]	Three-fourths can, once daily	150 (628)
Science Diet Canine Maintenance Light, dry[a]	One cup, once daily	221 (925)
Milk-Bone treats (small)	Two treats, daily	40 (167)
Total = 411 kcal/day (1.72 MJ)		

Table 3. Feeding plan to stabilize reduced body weight.

Foods	Feeding method	kcal (kJ)
Science Diet Canine Maintenance, moist	One-half can, once daily	278 (1,163)
Science Diet Canine Maintenance, dry	One cup, once daily	327 (1,368)
Milk-Bone treats (small)	Four treats, daily	80 (335)
Total = 685 kcal/day (2.87 MJ)		

CASE 27-2

An Overweight Cat

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Patient Assessment

An eight-year-old neutered male domestic longhair cat weighing 6.6 kg was diagnosed with asymmetric hypertrophy of the interventricular septum via echocardiography. No abnormalities were noted on physical examination except for excessive body weight. Complete blood count, serum biochemistry profile and urinalysis results were normal.

The cat's body condition was assessed as 4.5/5. Optimal body weight was estimated to be 5.5 kg, making the initial body weight 20% above ideal.

Assess the Food and Feeding Method

The cat was fed a commercial food that was lower in fat and higher in crude fiber than regular commercial cat foods (Science Diet Feline Maintenance Light;[a] one-third cup, twice daily).

Questions

1.Estimate the amount of energy consumed by this patient each day.
2. Calculate the daily energy requirement (DER) for this patient at its estimated optimal body weight and compare this number with the assessment in Question 1.
3. Outline a feeding and monitoring plan for weight reduction for this cat.

Answers and Discussion

1. The energy consumed by the cat each day was approximately 168 kcal (703 kJ). This is estimated from the dry food (two-thirds cup, 248 kcal/cup [1,038 kJ]).
2. The resting energy requirement (RER) at the estimated optimal body weight is calculated as follows: RER optimal weight = $70(5.5)^{0.75}$ = 250 kcal (1,046 kJ). DER at optimal body weight would be approximately 1.2 x RER or 300 kcal (1,255 kJ). The daily caloric intake estimated in Question 1 is actually lower than the RER for optimal body weight.
3. The cat was switched to a commercial dry feline food that had a slightly higher fiber content but approximately the same fat content and caloric density as the current food (Prescription Diet w/d Feline;[a] one-third cup twice daily, 165 kcal/day [690 kJ]). This food supplied only 66% of the calories estimated for RER at the optimal body weight. The owner was instructed to increase the cat's activity as much as possible and asked to return every two weeks for the first couple of months to weigh the cat and monitor the progress.

Progress Notes

Figure 1 shows the weight loss that occurred with this feeding and exercise plan. Note that the initial weight loss stopped by Week 13. At that time, the amount of food was reduced to one-fourth cup, twice daily, which supplied 123 kcal (515 kJ) or 49% of RER at optimal body weight. The two times when body weight increased were associated with the cat being fed by other people because the owner was out of town for several weeks. These lapses emphasize the need to have everyone understand the need for adhering to and measuring the prescribed amounts of food. The cat's owner understood the need for strict adherence to the feeding schedule, but those who fed the cat in the owner's absence did not. Some decrease in exercise level may also have occurred in the owner's absence.

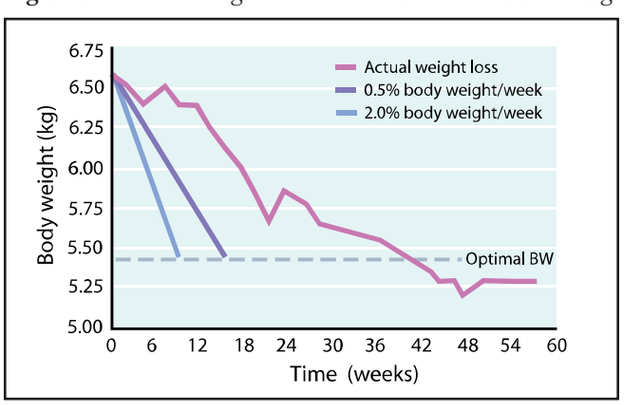

Figure 1. Progression of body weight loss compared with minimum and maximum rates of weight loss.

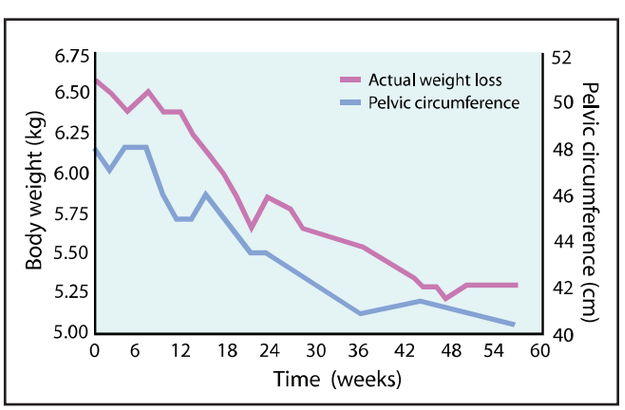

Figure 2. Comparison of body weight loss and decrease in pelvic circumference during the weight-reduction program.

Figure 2 compares weight loss with measurements of the cat's pelvic circumference. This shows how the pelvic circumference can be used along with body weight to track relative progression of weight loss.

Weight was stabilized at 5.3 kg by returning the cat to the original food and increasing daily caloric intake to 165 kcal (690 kJ). This was done in two steps. On Week 43, the food was changed to Science Diet Feline Maintenance Light;[a] one-fourth cup was fed in the morning and one-third cup in the evening. This feeding plan provided 144 kcal (602 kJ) per day. Weight loss slowed but body weight still tended to decrease. On Week 47, the food was increased to one-third cup twice daily and body weight stabilized.

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Endnote

a. Hill's Pet Nutrition, Inc., Topeka, KS, USA. Science Diet Feline Maintenance Light is currently marketed as Science Diet Light Adult Feline.

CASE 27-3

Lameness in an Obese Labrador Retriever

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Patient Assessment

A nine-year-old neutered female Labrador retriever weighing 41.8 kg was admitted six months after repair of a ruptured left anterior cruciate ligament. The dog was still limping on its left rear leg. Radiographs of the stifle showed evidence of mild osteoarthrosis. Orthopedic examination of the stifle for stability and range of motion was normal. No other abnormalities were found on physical examination. Results of a complete blood count, serum biochemistry profile, urinalysis and serum T_3 and T_4 concentrations were normal.

The dog's body condition was assessed as 4.5/5. Ideal body weight was estimated to be 34 kg (**Table 27-3**). Morphometric measures estimated 35% of the dog's body weight was fat.

Assess the Food and Feeding Method

Caloric restriction had been initiated after surgery in an attempt to promote weight loss. **Table 1** lists the assessment of the foods and feeding management. No weight loss had occurred in the last three to four months.

Questions

Table 1. Foods and feeding method assessment of an obese Labrador retriever with lameness.

Foods	Feeding method
Prescription Diet r/d Canine, moist[a]	One can, twice daily
Prescription Diet r/d Canine, dry[a]	One cup, twice daily
Milk-Bone treats (small)[b]	One treat, once daily

1. What are some risk factors for obesity that can be identified from the animal assessment?
2. Estimate the amount of energy consumed by this patient each day.
3. Calculate the daily energy requirement (DER) for this patient at its estimated optimal body weight and compare this number with the assessment in Question 2.
4. Outline a feeding, exercise and monitoring plan for weight reduction for this dog.

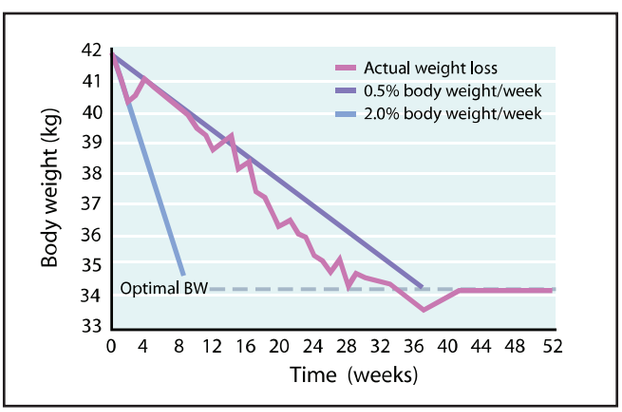

Figure 1. Progression of body weight loss compared with minimum and maximum rates of weight loss.

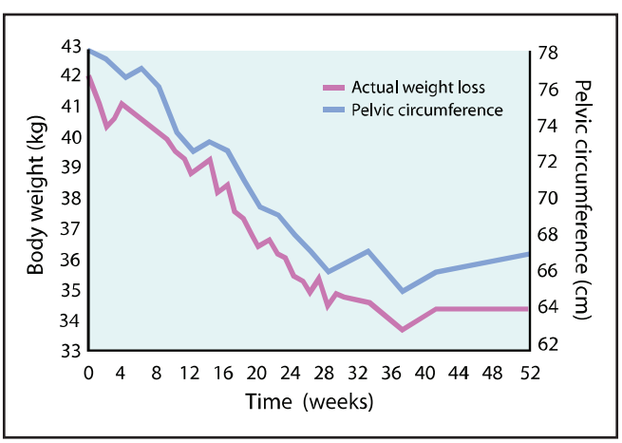

Figure 2. Comparison of body weight loss and pelvic circumference during the weight-reduction program.

Answers and Discussion

1. Risk factors for obesity in this patient include age (middle-aged dogs are more prone to obesity than younger animals), gender (female dogs are at higher risk than male dogs), reproductive status (neutered dogs are at more risk than intact animals), breed (Labrador retrievers are considered an obesity-prone breed) and exercise level (the dog had been sedentary since the knee surgery). Obesity may have contributed to the anterior cruciate rupture and restricted exercise since surgery may have contributed to persistent obesity despite recent caloric restriction.
2. The energy consumed by the dog each day was approximately 920 kcal (3.85 MJ). This is estimated from the moist food (two cans, 250 kcal/can [1.05 MJ/can]), dry food (two cups, 200 kcal/cup [837 kJ/cup]) and commercial treats (one treat, 20

kcal/treat [84 kJ/treat]).

3. The resting energy requirement (RER) at the estimated optimal body weight is calculated as follows: RER optimal weight = $70(34)^{0.75}$ = 988 kcal (4.13 MJ). DER at optimal body weight would be approximately 1.4 to 1.6 x RER or 1,383 to 1,581 kcal (5.79 to 6.62 MJ). The daily caloric intake estimated in Question 2 is actually lower than RER for optimal body weight.
4. Because the current intake of 920 kcal (3.85 MJ) was slightly less than RER for an optimal weight of 34 kg, this level of caloric restriction was not initially changed. Because the dog had been minimally active since the knee surgery, 20 to 60 minutes of persistent leash walking per day was initiated. The owners were instructed to work up gradually to whatever amount of walking the dog could do comfortably without soreness. The owners were asked to return every two weeks for the first couple of months to weigh the dog and monitor progress.

Progress Notes

Figure 1 shows the weight loss that occurred with this feeding and exercise plan. Loss of almost 2% of starting weight (the maximum acceptable rate of weight loss) was achieved during the first two weeks by the addition of exercise. Unfortunately, weight was actually gained during Weeks 3 and 4, which greatly discouraged the owners. The owners were counseled to persist with the leash walking and the daily caloric intake was decreased to 725 kcal/day (3.03 MJ) (approximately 80% of calories indicated by the dietary assessment) using the foods and feeding methods listed in **Table 2**.

After the dog had lost approximately 3 kg by Week 10, it ceased to limp and had a normal gait thereafter. The owners were unable to walk the dog during Weeks 12 to 14 and some weight gain occurred. Weight loss continued when leash walks were resumed. This finding demonstrates the importance of exercise as a component of daily energy expenditure, especially during weight reduction of calorically efficient animals.

Figure 2 compares weight loss with measurements of the dog's pelvic circumference. This shows how the pelvic circumference can be used with body weight to track relative progression of weight loss.

Calories were increased on Week 28 to maintain a body weight of 34 kg (**Table 3**). This dog maintained the reduced weight on the same number of kcal as it used to maintain the obese weight. This indirectly supports the assertion that adipose tissue requires very few calories to maintain its mass.

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Endnotes

a. Hill's Pet Nutrition, Inc., Topeka, KS, USA.
b. Nabisco, East Hanover, NJ, USA.

Table 2. Feeding plan for further weight reduction.

Foods	Feeding method	kcal (MJ)
Prescription Diet r/d Canine, moist	One-half can, morning	125 (0.52)
Prescription Diet r/d Canine, dry	One and one-half cups, twice daily	600 (2.51)
Total = 725 kcal/day (3.03 MJ)		

Table 3. Feeding plan to stabilize reduced body weight.

Foods	Feeding method	kcal (MJ)
Prescription Diet r/d Canine, moist	One-half can, twice daily	250 (1.05)
Prescription Diet r/d Canine, dry	One and two-thirds cups, twice daily	668 (2.80)
Total = 918 kcal/day (3.85 MJ)		

CASE 27-4

Weight Loss in a Domestic Shorthair Cat

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Patient Assessment

A 10-year-old, neutered female domestic shorthair cat was examined for routine geriatric health maintenance. The patient weighed 4.8 kg and its ribs were very difficult to feel under a thick fat cover. A moderate-to-thick fat layer covered bony prominences. The cat's abdomen was pendulous with no obvious waist. A marked abdominal fat pad was present and the cat's back was broadened when viewed from above. The cat's limbs also had fat deposits. Results of a complete blood count, serum biochemistry profile and urinalysis were normal.

Assess the Food and Feeding Method

The cat was fed a dry, specialty brand adult cat food free choice and was given one can of moist, grocery store brand cat food twice weekly as a treat.

Questions

1. What is the body condition score (BCS) for this patient?
2. What are risk factors for obesity in cats?
3. What types of therapeutic foods are available to help manage overweight or obese cats?
4. Are there clinical studies supporting the use of therapeutic foods for effective weight loss in cats?

Answers and Discussion

1. The physical examination findings support a diagnosis of obesity (BCS 5/5).
2. This cat has several risk factors for obesity. Middle-aged and older cats are more prone to obesity than younger animals. Female cats are at higher risk than male cats. Neutered cats are at greater risk than intact animals. Studies have shown that neutered cats require up to 30% fewer calories per day than before they were neutered. Strictly indoor cats usually are less active.
3. Traditional methods of weight management include use of low-calorie, high-fiber foods. Added fiber increases bulk and reduces hunger, while diluting calories. Weight-management foods often contain added L-carnitine, which helps cats lose fat safely, while maintaining lean body mass. An alternative weight-management concept for cats includes using a low-carbohydrate, high-protein food to alter a cat's metabolism for effective weight loss. When carbohydrates are unavailable, the body burns body fat and dietary protein as energy sources. When fed this type of food, cats lose weight and have improved glucose and lipid control. Food choice is based on veterinarian discretion and response to previous weight-management programs. Regardless of the food chosen, caloric restriction should be instituted and the amount of food fed should be closely monitored.
4. A study was conducted in which middle-aged or senior domestic shorthair cats with more than 30% body fat were fed either a low-calorie, high-fiber formula (Prescription Diet r/d Feline[a]) or a low-carbohydrate, high-protein formula (Prescription Diet m/d Feline[a]) for 24 weeks. Cats were fed to achieve ideal body weight and condition, which typically means 20% body fat. Each cat was fed its assigned food until it achieved 20% body fat or completed the 24-week study. More than 70% of each group reached ideal body weight within 20 weeks. Weight loss was well within the 0.5 to 2% of initial body weight per week recommended for safe weight loss by veterinary nutritionists. Importantly, both groups maintained lean body mass.

   After two months of feeding, cats fed the moist, low-carbohydrate, high-protein formula had twice the levels of beta-hydroxybutyrate (a ketone) as cats fed the moist, low-calorie, high-fiber formula. This finding signals a metabolic shift from using dietary carbohydrates to body fat as a primary energy source. These metabolic changes contributed to the weight loss in cats fed the low-carbohydrate, high-protein formula. Biochemistry profile data indicated no abnormal changes in organ function in either study group. Both the traditional, low-calorie, high-fiber food, and the low-carbohydrate, high-protein, metabolic control food, were safe and effective for weight loss in cats.

Progress Notes

The cat was fed a dry, low-carbohydrate, high-protein food (Prescription Diet m/d Feline) to help achieve weight loss. The amount of food was calculated based on an ideal body weight of 3.41 kg (daily energy requirement for weight loss = 0.8 x resting energy

requirement). The amount of food was carefully measured and divided into at least two or more daily meals (typically, 1/8th cup of food, twice daily). The owners were told that successful weight loss depends greatly on avoiding common pitfalls such as feeding their cat treats.

After three months, the cat weighed 3.95 kg, which represented a loss of 0.86 kg or 18% of its original body weight. After four months, the cat weighed 3.82 kg, and was losing 1.3% of initial body weight per week. Serum biochemistry, urinalysis and physical examination findings remained normal during the weight-loss period, proving the safety and efficacy of the program. This feeding plan was continued until the cat reached an ideal weight of 3.41 kg. The cat was transitioned to a dry, low-calorie, moderate-fiber food (Prescription Diet w/d Feline[a]) over seven days to help maintain ideal weight. A moist, low-calorie, moderate-fiber food (Prescription Diet w/d Feline) was recommended as snack offerings in place of the previous moist, grocery brand products.

Endnote

a. Hill's Pet Nutrition, Inc., Topeka, KS, USA

Bibliography

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