Canine and feline obesity

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The licensing arrangements for therapeutic agents intended for use in small animal species vary greatly worldwide. In the absence of a specific licence, consideration should be given to issuing an appropriate cautionary warning prior to administration of any such drug.
This paper will review the epidemiology of obesity in the dog and cat. Several epidemiological factors are common to both species, whilst others differ and these will be discussed separately.

**Incidence rate**

The incidence rate of obesity in dogs presented for consultation varies from 24 to 44% depending on the author, the site of the epidemiological study, and the definition of initial criteria (Table 1). All of the studies that have been performed in veterinary clinics in industrialized countries give a prevalence of obesity in dogs of at least 20%. The epidemiological data does not indicate whether the frequency of obesity has increased over the last 10 years, however obesity is a major medical problem in the canine population.

In the cat, the incidence rate of obesity, which was very low in the 1970’s, now exceeds 20%, regardless of the site of the epidemiological study.

**Risk factors**

Table 2 summarizes the various risk factors for
obesity and compares them between dogs and cats. Some risk factors are associated with energy intake, others with energy expenditure, whilst several factors act on both intake and expenditure.

Energy supply comes from ingested, digested and metabolized food. In mammals, expenditure can be classified into three categories: basal metabolism in mammals, postprandial thermogenesis and physical activity, representing 60, 10 and 30% of energy expenditure respectively. The contribution of each of these components varies significantly, according to the frequency and intensity of physical activity, which is the key variable in the expenditure side of the energy equation. However, basal metabolism would appear to be a stable independent factor, which is primarily determined by the proportion of lean body mass (accounting for 90-95% of basal metabolic energy expenditure compared to 5 to 10% for the fat mass) (Figure 1). In the dog, basal metabolism represents between 55 and 70% of the total expenditure.

**Breed**
The breed of the animal is a risk factor for obesity in...
dogs, but authors differ on the relative incidence of predisposed breeds. Some breeds have been acknowledged for decades, whilst others seem to be emerging, most notably the longhaired giant breeds. The pressures on breeding (changing show standard, popularity of the breed, change of use [e.g. working breed to pet breed],) and type of selection may influence the body condition (and weight) of dogs, for example by substituting beauty or conformational criteria over working aptitude (Figure 2). Breed predispositions to obesity are partly linked to genetic factors and more specifically to the lean/fat mass ratio.

Conversely, some breeds appear to be somewhat resistant to obesity: these include Greyhounds and the various sheep herding breeds. Note, however, that in a study carried out in Germany, German Shepherd Dogs, Poodles (Figure 3) and Boxers were often obese (1). This demonstrates the importance of local factors affecting perceptions of breed predisposition to obesity.

Not all the dog breeds are equal in terms of nutritional risk during growth. Excess energy intake predisposes small breed dogs to excess weight gain whilst in large breeds, the major risk of excess energy intake is osteoarthritic disorders. The combination of articular problems and excess weight is however common at the end of the growth period in large dogs.

In the cat, there is no reported breed predisposition to obesity. Indeed, one breed, the Abyssinian, does not appear to be affected. The majority of obese cats are cats of the so-called “domestic” breeds (crossbreeds, domestic shorthairs).

Other genetic factors
Mammals have a complex system of genetically determined factors that are designed to maintain the equilibrium between food intake and energy expenditure. Whatever the reason, some individuals become obese whilst others, living under the same conditions, maintain their ideal body weight.

The genetic alterations that lead to obesity in the dog are not yet fully understood, although there is no doubt about the polygenic nature of obesity. However, it is undeniable that genetic factors have an active role: obesity is particularly common in certain breeds of dogs as well as in certain lines.

Age
The incidence rate of obesity increases with the age of both the dog (2) and owner (3). Thus, some 6% of bitches aged 9 to 12 months are obese, whereas some 40% of adult female dogs are obese (4). The mean age at the time of diagnosis varies from 5 to 8 years. Fewer than 20% of dogs aged 4 years and under are obese, compared to more than 50% of dogs in the 7 to 8 year-old category, and nearly 70% of those aged over 9 years of age. However, recent data shows that the frequency of obesity decreases in animals aged over 12 years (5).

During aging, both lean/fat mass ratio and basal metabolism have a tendency to decrease (6).

It should be noted that excess weight in puppyhood predisposes to obesity in the adult. Obese bitches between 9 and 12 months of age have 1.5 times more chances of becoming obese in adulthood than bitches that are lean during the growth period (4).

In the cat, the risk is greatest between the ages of 5 and 10 years; it then strongly decreases over the age of 10 years.

Gender and neutering
Dogs
Females represent at least 60% of obese dogs. In
addition, a study by Glickman, et al. (4) involving 289 adult bitches reported a 40% incidence of obesity.

Gonadectomy increases the incidence rate of obesity in the male and especially the female (3). Edney and Smith (3) have reported that neutered bitches are twice as likely to become obese as intact females. A recent study demonstrated that this also applies to males. According to Robertson (7), the frequency of obesity is 32% in neutered animals, compared to 15% in entire dogs, both male and female. The sex hormones are not primary regulators of metabolism; however, they influence food intake and body weight both directly, by acting on the central nervous system, and indirectly by altering cell metabolism. The estrogens exert an inhibitory effect on food intake. Food intake therefore varies throughout the cycle in the female. It is minimal around the time of estrus, increases during metestrus and is maximal during anestrus (8).

The effect of early neutering on the incidence of obesity is unknown. A recent epidemiological study demonstrated that the incidence rate of obesity was lower in a population of dogs neutered before 5.5 months of age than in animals neutered between 5.5 and 12 months. The authors also report an overall incidence of obesity of 27% in the population of neutered dogs (9).

The increase in the practice of neutering in the canine population may explain the increase in obesity since the first epidemiological studies were performed in 1960. Furthermore, as this practice is becoming more and more widespread, a further increase in incidence is to be expected over the next few years, including in countries that up to now have been relatively free of the problem.

Although it is difficult to clarify the link between neutering and obesity, due to the multi-factorial nature of the latter, several explanations may be proposed:

- The first point to be considered is the variation in food intake over the cycle as reported above, and the inhibitory effect of estrogens on food intake. It is therefore logical to think that this inhibition is no longer effective in neutered bitches. During the first three months after neutering, 4 female Beagles consumed 20% more food than entire control animals, and their body weight subsequently increased significantly (8).

- Another study has investigated this problem, by measuring not the increase in weight in neutered females but the actual quantities of energy required to maintain a body weight - considered as being ideal - in Beagle bitches. A 30 % decrease in daily energy intake in comparison with the ration provided prior to neutering was found to be necessary in the weeks following ovariohysterectomy to maintain the bitches at their ideal weight (10).

- Neutering also causes a decrease in spontaneous activity, especially in males. This last point is difficult to quantify under experimental conditions.

Weight gain following neutering could therefore be prevented by strict rationing and regular exercise. In a study with working dogs (German Shepherds) subjected to regular exercise and receiving the same amount of food, no difference in body weight was demonstrated between neutered and entire dogs. This data tends to prove that maintaining regular exercise after sterilization can prevent weight gain (11).

Cats

Castrated cats are 3 to 4 times more likely to be obese than entire individuals, and males are more often affected than females, who have a higher resting metabolic rate. The increased body weight of neutered cats has been proven experimentally; however, these trials did not elucidate the exact cause of the problem. One can however confirm the hypothesis that the removal of estrogens plays a major role in metabolic regulation. Recent studies have demonstrated that they inhibit lipogenesis and are determining factors for the number of adipocytes, even in males (12).

It has been clearly established that onset increased energy intake in male cats was rapid - from the 1st week after the neutering - and significant: to the order of 15% (week 1 after neutering) to 80% (week 7). This increased food intake after several weeks induced an increase of around 30% in body weight, mainly in the form of fat. Hormones such as insulin and leptin, increased, but did not play their role of appetite regulation.

Energy expenditure also seems to be reduced following neutering. However, since the activity and behavior of animals kept indoors are little changed, the decreased energy expenditure is related to a decrease in the basal metabolic rate. The exact mechanisms are still not fully understood.

Finally, it should be emphasized that the age of the cat at the time of neutering has no effect on the development of obesity.
**Contraceptive treatments**

During a clinical trial, contraceptive treatment using medroxyprogesterone acetate led to a significant weight gain in 17.4% of treated bitches. The authors reported bulimia and obesity in some animals (13).

**Obesity and endocrine disorders**

In the dog, obesity may be associated with certain endocrine disorders such as diabetes and hypothyroidism. At least 40% of dogs that suffer from one of these diseases are obese. Obesity may also be secondary to hyperadrenocorticism (Figure 4). In a clinical study, 5 out of 8 dogs presented with fat deposits typical of obesity and different from a pendulous abdomen.

**Obesity secondary to medication**

Some drugs may lead to hyperphagia and secondarily excess body weight; the primary culprits are the antiepileptics and glucocorticoids.

**Sedentary lifestyle and lack of exercise**

**Dogs**

In the dog, a lack of exercise is a fundamental factor in the development of obesity: the prevalence of obesity decreases in proportion with the duration of weekly exercise. It is however impossible to determine whether the obesity is responsible for exercise restriction or whether it is the lack of exercise that contributes to the development of obesity. The duration of weekly exercise is a more precise criterion than the type of habitat for evaluating energy expenditure. Dogs living in flats or in a house are generally more obese than dogs living outdoors (31% versus 23%) (2). Nevertheless, it is erroneous to believe that the availability of a large garden systematically increases energy expenditure. Some animals living in a confined environment are taken out for walks several hours per week, whilst others, with a garden available, are content to make use of it for only a few minutes each day.

**Cats**

The cat is a predator whose feeding behavior in the wild is linked to hunting. Predatory activity therefore takes up two thirds of its time. Moreover, in the wild, only one out of every 15 hunting expeditions is successful. The cat is therefore used to short periods of intense activity leading to energy expenditure. It should be remembered that eating is not a social activity in the cat, which is a solitary animal. Hunting and eating are motivated by factors that are independent of one another. Playing and grooming are also activities that consume energy, and which may be modified in indoor cats.

Our domestic cats have little in common with their wild relatives:
- They live an extremely sedentary lifestyle, are neutered and often overfed
- Their owners are often ignorant of their behavioral needs: living in a restricted space with a lack of daily exercise, both in terms of duration and intensity
- Sedentary cats generally sleep longer than non-domestic cats (12 to 18 hours versus a maximum of 12 hours), which may greatly influence energy expenditure and as a result body weight control (Figure 5)

**The type of food and miscalculation of energy requirements**

The following nutritional causes have been clearly identified and are common to both dogs and cats:
- Food intake that does not take into account energy requirements
- *Ad lib* feeding, "my animal eats everything that I give it"
- Supplements in the form of titbits or fatty acid supplements that are not accounted for in the total energy supply
- The provision of very appetizing food, rich in fats and soluble sugars

An undeniable risk factor is *ad libitum*, feeding leading to excessive energy intake. *Ad lib* feeding is not advisable as the majority of dogs and cats are unable to regulate their food intake, particularly when the energy concentration (and therefore the fat content) of their
diet is high. The fattest foods are often the most highly concentrated in energy, often the most flavorsome and fats are very well digested and stored by domestic carnivores. Offering titbits, leftovers of the owner’s meal and various nutritional supplements are additional risk factors (2).

There is controversy over the influence of restricted rations on the development of canine obesity. The underlying idea is that dogs who receive restricted rations will be more often “rewarded” with titbits and end up receiving larger amounts of food. This view can only be supported in countries where dogs are still fed in a “traditional” way, with restricted rations or table scraps. In North America, 95% of animals receive commercial feeds and yet canine obesity does not seem to be any less prevalent than in some European countries. In fact it is quite the opposite.

A recent epidemiological study demonstrated that the type of food (wet versus dry) did not have any significant effect on the incidence rate of canine obesity (2). Unlike some widely held views, offering an adapted daily ration in several smaller meals does not lead to an increase in the frequency of obesity. In most epidemiological studies, the obese dogs are fed once daily (2, 14). Naturally, one should not confuse the division of an appropriate daily ration with the multiplication of various treats that are added to it.

**The social dimension of food**
The possession of several animals may pose the problem of controlling individual consumption. However, obesity is more common in households that have only one dog (2, 14).

In the cat, the risk of obesity is greater in animals that live alone or with one other cat, in comparison with households with 3 or more cats.

The role of feeding in the relationship between man and his domestic pet plays a major role in the development of obesity. As shown by a recent study (14), this relationship is characterized by an excessive anthropomorphic behavior, or even anthropocentrism. For example, the owners of obese dogs talk to their dogs more, allow their animal to sleep with them, do not fear zoonotic diseases, and consider that exercising, working, or guarding the house are not important for the dog. It is of no surprise therefore to note that obese animals receive meals or treats more often than animals of a normal weight. The owners of obese animals interpret any demand from the animal as a demand for food. These owners clearly do not worry about providing a balanced diet. Some of these aspects are well known to practitioners, but this study had the merit of making it more objective by using a questionnaire (14).

The data presented above may appear to be fairly discouraging at first glance, and they do not enable a clear differentiation to be made between simple correlations (for example, between the weight of the owner and the weight of the dog) and the causes of obesity. They are however very useful for the development of preventive and corrective programs for canine obesity. They draw attention to environmental factors, in the broad sense of the term, which are theoretically exterior to the animal itself, but of fundamental importance for its health.

**Associated pathology**
Up until the end of the 1980’s, there were relatively few data available on obesity-linked diseases in the dog and cat. Also, some authors extrapolated data from epidemiological studies performed in man. However, the simple transposition of human data (diabetes, hypertension, etc.) to the obese dog or cat does not provide all the answers. Clinical data, which is being published more and more often, needs to be carefully studied (See Alex German’s paper on page 21).

It should be noted that several reported disorders are reversible. Thus, exercise intolerance (Figure 6), inactivity, and musculoskeletal or respiratory disorders are generally reduced or may totally disappear. Reversible metabolic disorders include disorders such as insulin-resistance and dyslipidemias.

**Figure 6.**
Male castrated English Bulldog, presented for a clinical nutrition consultation at the request of the surgeons. This dog must lose weight prior to undergoing surgery. He weighs 33kg and is suffering from brachycephalic syndrome and exercise intolerance (Photo. Dr. E. Lhoest, FMV, ULg 2005).
Conclusions
A sound knowledge of risk factors and associated pathologies is vital for the instigation of means for the effective disease prevention. It would appear that the major factors in the dog and cat include gonadectomy, a sedentary lifestyle, and the ignorance of the nutritional requirements and behaviors of these two species.
Introduction

The concept underlying obesity management is simple; weight loss occurs whenever daily energy expenditure exceeds daily consumption of calories. Yet it can be very challenging to implement successful weight loss programs for pet dogs and cats. The process of tailoring obesity management guidelines for individual cases is illustrated here using clinical examples. The key is to use detailed evaluation of diet history and lifestyle to first identify all the specific owner and animal constraints that will affect implementation of a weight loss program, and then to develop practical solutions that work within these constraints. The aim is to make it as easy as possible for owners to comply with their pet’s obesity management regimen. It is important to consider the individual companion animal-human bond and to provide ongoing support and guidance so that owner motivation and compliance are optimized.

In short, overweight dogs and cats just need to eat less and run around more. Despite the simplicity of this concept, it is very difficult to implement obesity management for pet dogs and cats. Owners frequently find it challenging to maintain compliance and motivation for weight loss programs, even when they believe that their pet’s health will be improved by reduction of excess body fat.

Specific owner and animal constraints can be identified for almost every case of pet obesity. It is these constraints that make the cases so complex...
and result in the management regimens being so difficult for owners to comply with. Success is dependent firstly on recognition of the constraints for each individual case, and secondly on development of effective solutions that work within these constraints.

The following examples illustrate the process of case evaluation and management for obesity problems in dogs and cats. The primary goal is always to reduce the animal’s daily consumption of calories and/or increase its daily energy expenditure. Emphasis is placed on detailed evaluation of diet history and lifestyle, and on identification of all the specific owner and animal constraints that will affect implementation of an obesity management program. Recommendations are then tailored for each individual case with the aim to make it as easy as possible for the owners to comply with all of the guidelines.

**Case 1: Jodie**

**Management strategy: education of the owner regarding their pet’s nutritional needs**

**Signalment:**
- 8 year old, neutered female, Labrador Retriever (**Figure 1**)

**Physical assessment:**
- Body weight = 44.7 kg
- Body condition score = 8.5 on a scale of 1 to 9 (4.7 on a scale of 1 to 5)

**Diet history:**

*Food:* Jodie’s staple diet is a nutritionally complete and balanced, prescription dry food formulated with protein hydrolyzate for dogs with food hypersensitivity (Metabolizable Energy (ME): 3.72 kcal/g). This diet has been fed for over 2 years and was prescribed when recurrent allergic otitis externa was diagnosed. Careful questioning reveals that a wide variety of additional foods are fed each day.

*Feeding method:* Two cups of the prescription dry food is fed once daily in the evening. This food is prepared by one of the owners who presented the animal, and grated cheese is added to improve palatability. Table scraps are frequently fed after the owner’s meal and are followed by ice cream for dessert. A slice of toasted bread with butter is given each morning, and occasionally bacon and eggs are also fed at this time. The presenting owner and two other family members feed a number of other foods sporadically during the day. All food is always consumed immediately.

**Lifestyle:**

Jodie is reported to have a low to moderate activity level. Her regular exercise regimen is a 30-minute walk every morning, and she also occasionally enjoys chasing balls. Recently, her mobility has markedly decreased but she is still managing two 10-minute walks each day.

**Specific owner and dog constraints identified for this case:**

Jodie’s owners do not understand why she is so overweight. They are highly motivated to implement obesity management because they believe that the excess body fat is having a negative impact on her health. They are concerned that she always appears to be hungry and cannot imagine how she could manage if fed less food. They do not recall the feeding guidelines that were recommended when the hydrolyzate diet was first prescribed, and have never fed the food exclusively for an elimination food trial. Recently, respiratory difficulty has limited Jodie’s ability to exercise and she now appears exhausted after 10 minutes of slow walking.

**Specific health issues identified for this case:**

Exercise intolerance with respiratory signs in this case is related to morbid obesity and weight loss is imperative to manage the problem. It is also suspected that concurrent osteoarthritis might be contributing to the dog’s decreased mobility. Chronic, allergic, otitis externa is also a problem and a short course of oral prednisolone has recently been prescribed. Jodie has almost completed the course of tablets and her ear canals are now much improved. However, exercise tolerance has decreased markedly since beginning the corticosteroids.

**Plan for obesity management:**

*Food:* The prescription, protein hydrolyzate, dry food is to be continued, and to be fed exclusively.

*Feeding method:* As the owners are willing to implement strict nutritional guidelines for obesity management, it is decided to also perform an elimination food trial for eight weeks to evaluate the role played by food allergy in the chronic, allergic otitis externa (2). It is recommended to begin by feeding 2 cups of food twice each day, and to
measure this precisely with a standard 250 mL measuring cup. This provides 1016 kcal/day and is the resting energy requirement for a 35 kg dog, which is estimated to be Jodie’s ideal body weight. Resting energy requirement (RER) can be calculated using the formula: RER (kcal/day) = 70 x (body weight in kg)^0.75 (Editor’s note: practitioners without scientific calculators can calculate BW^0.75 by using the following formula: BW x BW x BW, enter, and then v^v). A portion of the meals can be set aside to be fed as snacks throughout the day.

Physical activity: As Jodie is very exercise intolerant, it is emphasized that exercise should be limited to what she can manage comfortably.

Outcome:
Over the first 8 weeks of the obesity management program, Jodie has lost just 700g and her body weight has reduced by only 1.6% to 44.0 kg. However, her body condition score has decreased by a greater proportion to 7.5/9 (4.25/5), and progressive reduction of neck and waist circumference has occurred. Exercise intolerance and respiratory signs have resolved and she is able to resume 30-minute walks. Otitis externa is still present but signs are adequately controlled with topical therapy.

The greatest concern for the owners is that Jodie does not always eat all of her morning meal. They feel that the prescription diet is not sufficiently palatable and frequently seek advice on strategies to improve palatability. They believe that she is usually hungry because she always begs for treats when they are eating. They choose not to use a portion of the usual meals as snacks throughout the day because they believe that Jodie will not want these. Reinforcement of the importance of persisting with a strict elimination food trial is provided on several occasions. Great emphasis is also placed on the overall improvement in Jodie’s quality of life, with resolution of exercise intolerance and respiratory signs, and resumption of her usual walks. It is explained that appetite can be stimulated in satiated dogs by offering highly palatable food, and that begging for food is a manifestation of the human-animal bond, as well as an expression of hunger. The owners are encouraged to reflect on their own appetite with regard to different food items. Most people relish a healthy sandwich when hungry, yet decline to eat a similar sandwich when not hungry. Chocolate cake, on the other hand, is often desired and consumed by people even when they are not hungry. When this analogy is applied to Jodie, the prescription diet is likened to healthy sandwiches that are eaten well when the dog is hungry and refused when she is satiated, while pieces of cheese can be considered as palatable as chocolate cake.

Food intake is reduced to 1 cup of the prescription hydrolyzate diet in the morning and 2 cups in the evening (760 kcal/day). These results in all of the food being consumed at most meals. At the end of the elimination food trial when there is no apparent improvement in the otitis externa, Jodie’s owners are keen to change to a diet with improved palatability and decreased calorie density compared with the hydrolyzate diet. Two options are trialed and the owners choose a prescription dry food formulated for obesity management (ME: 3.02 kcal/g). Recommended calorie intake is 700 kcal/day fed as two separate meals. The otitis externa is carefully monitored after the dietary change and no clinical deterioration is noted. Regular reassessment is continuing and Jodie’s body weight and body condition are both progressively decreasing.

Comments:
In this case, the most important issue is to provide education and support for the owners of the dog. At the initial consultation, Jodie’s owners had no comprehension that she was being fed too many calories for her energy needs, or that a hydrolyzate diet is not meant to be supplemented with other foods such as cheese. An understanding of the nutritional needs of their pet is required for feeding guidelines to be effectively implemented. In addition, ongoing support is needed because the owners find it emotionally difficult to stop sharing a portion of their own food with Jodie.

Case 2: Toby

Management strategy: changing the feeding method

Signalment:
• 5 year old, neutered male, Cavalier King Charles Spaniel

Physical assessment:
Body weight = 16.4 kg
Body condition score = 7.5/9 (4.25/5)

Diet history:
Food: Toby’s staple diet is a nutritionally complete and balanced, grocery brand dry food, marketed as having a “lite” formulation for adult canine maintenance (ME: 3.54 kcal/g). He is also frequently fed snacks, including commercial dog treats (ME: 3.59 kcal/g), table scraps, and pieces of cheese.

Feeding method: A free-choice feeding method is used for Toby’s dry food. His bowl is topped up from a nearby storage container whenever the bowl is nearly empty. It is changed once daily for a clean bowl, and the dry food transferred. Snacks are fed by all family
members at the dinner table, at afternoon tea, and when they visit the pantry. Toby is also fed commercial dog treats and occasional pieces of cheese for good behavior or because he exhibits begging behavior to a family member.

**Lifestyle:**
Toby is described as having a moderately sedentary activity level. He is usually exercised two to three times weekly for 30 minutes, but this has been reduced recently because of lameness due to osteoarthritis.

**Specific owner and dog constraints identified for this case:**
Toby’s owners believe that he is a very finicky eater because he often will not eat his dry food. They say that he always prefers to eat a portion of their food. They admit that they all find it impossible to resist his pleading expression when he begs for food.

**Specific health issues identified for this case:**
Obesity management has been recommended because Toby has chronic lameness due to osteoarthritis.

**Plan for obesity management:**

**Food:** The nutritionally complete and balanced, “lite”, grocery brand dry food is to be continued. Additional food is to be restricted to the commercial dog treats.

**Feeding method:** Daily calorie intake will be restricted to 450 kcal. This is the resting energy requirement for a 12 kg dog, which is estimated to be Toby’s ideal body weight. One adult member of the household will precisely measure 120 g of the food each day and place it in a container. One of the commercial dog treats will be broken into pieces and added to the ration. Family members may then use the food in the container to provide as many small meals and snacks throughout the day for Toby as they wish. No additional food is to be fed.

**Physical activity:** Toby is to be walked every day, rather than two or three times a week. The aim is for a 30-minute walk every day, but the duration of the walk may be reduced if lameness is apparent.

**Outcome:**
The owners report that the container with Toby’s daily ration of food has become a major focus in the household. Toby soon refuses to eat any food from a bowl. Instead, the owners are required to hand feed individual kibbles of the food throughout the day. Toby develops the behavior of carrying each kibble of food to another room or outside the house before eating it. He then returns and begs for the next kibble. The owners believe that Toby enjoys this method of feeding and admit that they do as well. Their only concern is that they believe that the daily ration is too small and they run out of food each evening.

During the first 4 weeks, Toby loses 1.8 kg, which represents 2.7% weight loss per week. This rate of reduction is considered excessive because generally the objective is to achieve an average of 1-2% weight loss per week. The daily ration is increased to 160 g of the grocery brand food. The commercial dog treats are discontinued because the owners are no longer interested in feeding them.

Weight loss then proceeds steadily at a rate of approximately 1.5% per week and after a further 4 months Toby reaches ideal body condition at 11.8 kg. The quantity of the daily ration is then adjusted to maintain this.

**Comments:**
The companion animal-human bond plays a crucial role in obesity management programs for pets. Owners are often concerned that calorie restriction will be an important welfare issue. They believe that they will be depriving their pet if they do not give the animal food when it appears to be hungry. Significant owner pleasure is obtained from feeding Toby and this issue needs to be addressed. Successful obesity management is achieved in this case by changing the free-choice feeding method to one that involves maximum interaction between dog and owners.

**Case 3: Moppet and Mittens**

**Management strategy:** changing the type of food

**Signalment:**
- Two year old, neutered female, Burmese cats (Figures 2)
- Moppet and Mittens are littermates that live together in the one household

**Physical assessment:**
Moppet: Body weight = 7.7 kg; Body condition score = 8.5/9 (4.75/5)
Mittens: Body weight = 8.2 kg; Body condition score = 9/9 (5/5)

**Diet history:**
Food: Both cats are fed a nutritionally complete and balanced, “lite”, grocery brand dry food that is to be restricted. Additional food is to be restricted to the commercial cat treats. Feeding method: Daily calorie intake will be restricted to 450 kcal. This is the resting energy requirement for a 3 kg cat, which is estimated to be Moppet’s ideal body weight. One adult member of the household will precisely measure 120 g of the food each day and place it in a container. One of the commercial cat treats will be broken into pieces and added to the ration. Family members may then use the food in the container to provide as many small meals and snacks throughout the day for Moppet as they wish. No additional food is to be fed.

**Outcome:**
The owners report that the container with Moppet’s daily ration of food has become a major focus in the household. Moppet soon refuses to eat any food from a bowl. Instead, the owners are required to hand feed individual pieces of the food throughout the day. Moppet develops the behavior of carrying each piece of food to another room or outside the house before eating it. He then returns and begs for the next piece. The owners believe that Moppet enjoys this method of feeding and admit that they do as well. Their only concern is that they believe that the daily ration is too small and they run out of food each evening.

During the first 4 weeks, Moppet loses 1.8 kg, which represents 2.7% weight loss per week. This rate of reduction is considered excessive because generally the objective is to achieve an average of 1-2% weight loss per week. The daily ration is increased to 160 g of the grocery brand food. The commercial cat treats are discontinued because the owners are no longer interested in feeding them.

Weight loss then proceeds steadily at a rate of approximately 1.5% per week and after a further 4 months Moppet reaches ideal body condition at 11.8 kg. The quantity of the daily ration is then adjusted to maintain this.

**Comments:**
The companion animal-human bond plays a crucial role in obesity management programs for pets. Owners are often concerned that calorie restriction will be an important welfare issue. They believe that they will be depriving their cat if they do not give the animal food when it appears to be hungry. Significant owner pleasure is obtained from feeding Moppet and this issue needs to be addressed. Successful obesity management is achieved in this case by changing the free-choice feeding method to one that involves maximum interaction between cat and owners.
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**Feeding method:** The client who presented the cats for assessment is the only person in the household who feeds the cats. Food is supplied in two bowls. One bowl is on the floor and is used by both cats. The other bowl is on a bench and can only be accessed by Moppet. This is a strategy introduced by the owner to reduce weight gain in Mittens, who is the heavier cat and can no longer jump on to the bench to feed from the bowl there. A free-choice feeding method is used. Food is added to the bowls twice daily. Every 2-3 days, the food in the bowls is discarded, the bowls are cleaned, and fresh food is supplied. The owner has no idea how much food each cat consumes each day.

**Lifestyle:**
Both cats are kept indoors and their activity level is described as sedentary.

**Specific owner and cat constraints identified for this case:**
The owner is unwilling to attempt a change from a free-choice feeding method to a food-restricted meal feeding method, as this will not suit her lifestyle. She also believes that it will not be easy to increase the activity level of the cats because both animals are reluctant to engage in games that involve stalking, chasing, pouncing, or swatting.

**Specific health issues identified for this case:**
Burmese cats have an increased risk for developing diabetes mellitus (3, 4), particularly those that are confined indoors or have lower physical activity (5). The risk for developing diabetes is further increased in cats by obesity-induced insulin resistance and hyperinsulinemia (6). For Moppet and Mittens, successful weight management will reduce the risk for developing diabetes later in life.

**Plan for obesity management:**

**Food:** Change the food to a nutritionally complete and balanced, prescription dry food with restricted dietary carbohydrate content. The recommended diet has lower calorie density (3.96 kcal/g) and greatly reduced dietary carbohydrate content (13%ME), compared with the previous diet (ME 4.28 kcal/g; carbohydrate content 37%ME).

**Feeding method:** Initially, the recommendation is to continue using the free-choice feeding method as the owner is reluctant to change this. A meal feeding method might be required if obesity management is not successful with continued free-choice feeding. The owner is encouraged to quantify the amount of food consumed by the cats each day as this information will help to determine the appropriate meal size if the feeding method is to be changed.

**Physical activity:** Several options for increasing physical activity of the cats are discussed and a range of potential toys shown as examples. As the cats are reluctant to engage in direct play with the owner, the suggestion is made that favored items and portions of food be distributed throughout the house when the owner leaves for work for the cats to ‘discover’ during the day.

**Outcome:**
Gradual reduction in body weight and body condition is sustained in both cats over the following 7 months. At each reassessment, the owner reports that she has not been able to quantify the amount of food consumed by the cats each day but that they don't seem to be eating as great a volume of food as they had previously. She is very pleased with the outcome because she has been able to continue using the free-choice feeding method. The owner also reports that one of the cats, Mittens, has become very bonded to one particular toy, and will seek out the toy, play with it, carry it around in her mouth, and sleep with it near her.

After 7 months, both cats achieve ideal body condition [5/9 (3/5)] and weigh 5.8 kg and 5.5 kg, respectively (Figures 3). No changes are made to the feeding regimen, and further reassessment identifies stable body weight and condition over the next 6 months.

**Comments:**
In this case, the risk for developing diabetes mellitus is considered much greater than average. The frequency of diabetes in the Burmese breed is approximately four times the rate in Domestic cats in Australia; with 1 in 50 Burmese affected compared with less than 1 in 200 Domestic cats (7). The risk for Mittens and Moppet was likely further increased by the effects of excess body fat because many obese cats are glucose intolerant and hyperinsulinemic (6). Thus, nutritional intervention to lower postprandial glucose and insulin concentrations by restricting dietary carbohydrate intake was considered important (8).

When the diet was changed from a premium dry food formulated for maintenance of less active, adult cats, to a prescription dry food with restricted dietary carbo-hydrate content, the apparent food intake of the cats decreased and gradual reduction of body weight and condition to ideal was achieved despite continued free-choice feeding. This might have been because the low carbohydrate, high balanced, premium dry food formulated for maintenance of less active, adult cats (ME: 4.28 kcal/g). No treats or other foods are fed.
protein prescription diet was associated with greater satiety. Alternatively, the cats might have found this diet less palatable than the premium food.

**Case 4: Holly**

**Management strategy: increasing activity level**

**Signalment:**
- 7 year old, neutered female, Domestic Shorthair cat

**Physical assessment:**
- Body weight = 7.6 kg
- Body condition score = 8/9 (4.5/5)

**Diet history:**
- **Food:** The staple diet is a prescription, restricted-calorie, dry food formulated for weight loss (ME: 3.02 kcal/g). Occasionally, a treat comprising a single kibble of the other cat’s premium, hairball control, dry food is fed (ME: 3.89 kcal/g).
- **Feeding method:** 50-60 g of food divided into 4 meals per day. The presenting owner is the person who feeds the cat and carefully measures the portion of food each day. All food is always consumed immediately. Although the two cats in the household are fed separately, Holly occasionally manages to steal 5-6 kibbles of the hairball control food.

**Lifestyle:**
Holly is kept indoors and her activity level is described as sedentary.

**Specific owner and cat constraints identified for this case:**
The owner has been following an obesity management program for Holly for 15 months and is frustrated because the rate of weight loss is too slow. Since starting the program, Holly has lost 1.1 kg, which is less than 1% weight loss per month. The owner feels that the cat is always hungry and is not prepared to further restrict calorie intake because she believes that this will negatively affect Holly’s quality of life.

**Plan for obesity management:**
- **Food:** No change
- **Feeding method:** No change
- **Physical activity:** Options for increasing physical activity are discussed and a range of potential toys shown as examples. It is explained that the key is to encourage playful, kitten-like behavior. Cats tend to like to stalk, ambush, and pounce when playing. Devices that resemble a fishing rod with a toy dangling at the end are popular for exercising cats, as are items secured at the end of a piece of wire that flexes in an erratic and unpredictable manner. Another simple method involves blowing bubbles for the cat to chase using a child’s bubble-ring and soapy water. Some cats can be easily encouraged to follow their owner around the house for 5-15 minutes per day. It is not necessary for the cat to be constantly moving throughout the exercise period. Physical activity in cats naturally occurs in sporadic stops and starts. Children often enjoy being given the task of exercising a cat.

**Outcome:**
There was initially some difficulty with encouraging Holly to increase her activity level, and she could not be engaged in playing with any of the toys. Eventually a game was found that Holly seemed to enjoy. Holly’s owner named this game “bed mice” and described that when she moved her hand under the bed covers while the cat was on top of the covers, Holly could be encouraged to chase and pounce on the hand. This game was played for 5-15 minutes each day, and after a few weeks, the owner reported that the cat’s general activity level and interest in life seemed to improve. Holly appeared to look forward to the game and would sit at the door to the bedroom waiting for the owner to come and play.

During the following 12 months, Holly doubled her rate of weight loss, and achieved ideal body condition at a body weight of 5.7 kg.

**Comments:**
Recent research indicates that daily exercise of the type described here is an effective means of managing obesity in cats, and can be used alone or in conjunction with calorie restriction (9-11). Additional benefits of
incorporating play activity into the daily routine include the introduction of a form of owner-cat interaction that does not involve feeding, and the perception by the owner that their cat’s quality of life is improved.

Conclusion
These four cases illustrate how obesity management programs can be individualized for dogs and cats. Success relies on accurate collection of a detailed diet history, honest communication about lifestyle, identification of specific owner and pet constraints, and ongoing support and guidance. Consideration of the individual companion animal-human bond is always very important. Developing regimens that work within the constraints of this bond and are easy for owners to implement make for longer-term success. If the specific limitations of each case are addressed in this manner, motivation and compliance are optimized. Ultimately, the key is to find the most practical balance between increasing daily energy expenditure and decreasing daily consumption of calories.

**REFERENCES**

Introduction

Obesity is the most prevalent form of malnutrition in veterinary medicine. Surveys suggest that 25% to 30% of dogs and cats presented to veterinary clinics are overweight (1-3). Obesity is defined as a pathological condition characterized by an accumulation of fat in excess of that required for optimal body function. The significance of obesity pertains to its role in the pathogenesis of a variety of diseases and the ability to exacerbate pre-existing disease (4). The ability to accurately measure body fat would facilitate understanding the causes and effects of obesity and the response to weight reduction programs.

Numerous methods exist for the assessment of body composition (Table 1). However, techniques including densitometry, total body potassium, and neutron activation analysis are not readily available and the remainder of this discussion will focus on clinically relevant methods.

Body weight can be subdivided into two or more physiologically distinct components (Figure 1). The traditional two compartment model divides body weight into the fat mass (FM) and the fat free mass (FFM) (5, 6). This model forms the basis of the majority of our current knowledge of body composition, and is dependent upon assumptions regarding the character of the FM and the FFM (Table 2). The composition of the FFM is assumed to be relatively constant with a density of 1.1 g/mL at 37°C, a water content of 72-74%, and a potassium content of 50-70 mmol/kg (7). In addition, the major constituents of the FFM are presumed to be present in fixed ratios. In comparison, the FM is relatively homogenous in composition, anhydrous and potassium free with a density of 0.900 g/mL at 37°C.

The assessment of body composition in the form of FM and FFM provides valuable information about the physical and metabolic status of the individual. The FM can be considered to represent a calorie or

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**Table 1. Techniques available to measure body composition**

<table>
<thead>
<tr>
<th>Clinically relevant techniques</th>
<th>Research techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body weight</td>
<td>Densitometry</td>
</tr>
<tr>
<td>Body condition score</td>
<td>Computed tomography</td>
</tr>
<tr>
<td>Morphometric measurements</td>
<td>Magnetic resonance imaging</td>
</tr>
<tr>
<td>Body Mass Index</td>
<td>Total body electrical conductivity</td>
</tr>
<tr>
<td>Dilutional techniques</td>
<td>Total body potassium</td>
</tr>
<tr>
<td>Bioelectrical impedance analysis</td>
<td>Neutron activation analysis</td>
</tr>
</tbody>
</table>

**Table 2. Assumptions used to assess body composition**

<table>
<thead>
<tr>
<th>Fat Free Mass</th>
<th>Fat Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homogenous</td>
<td></td>
</tr>
<tr>
<td>Anhydrous</td>
<td>Potassium free</td>
</tr>
<tr>
<td>Potassium 50-70 mmol/kg</td>
<td>Density of 0.9 g/mL</td>
</tr>
</tbody>
</table>

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energy storage depot. Conversely, the FFM represents the actual health of the animal. It is a heterogeneous entity consisting predominantly of intracellular (ICF) and extracellular fluid (ECF), minerals, glycogen and protein. The FFM contains the body cell mass (BCM), which is the metabolically active part of the body responsible for determining most of the resting energy expenditure. BCM encompasses those lean tissues most likely to be affected by nutrition or disease over relatively short periods. Furthermore, the FFM is generally accepted as an index of protein nutrition and therefore changes in FFM over time are assumed to represent alterations in protein balance.

**Body weight**

Body weight is the simplest technique and should be included in the examination of every patient. It provides a rough measure of total body energy stores and changes in weight parallel energy and protein balance. In the healthy animal, body weight varies little from day to day. There can be wide variation between scales though, so it is important to use the same scale for an individual animal each time to avoid inter-scale variation. The major problem with body weight is that by itself, it has little meaning. Knowing that a Labrador Retriever weighs 31.76 kg (70 pounds) means little; the dog could be overweight, underweight, or in ideal body condition. Therefore, body weight should not be used in isolation.

**Body condition score**

The body condition score (BCS) provides a quick and subjective assessment of an animal’s overall body condition. The two most commonly used scoring systems in small animal practice are a 5-point system where a BCS of 3 is considered ideal or a 9-point system where a BCS of 5 is considered ideal. The BCS in conjunction with body weight gives a clinician a more complete perspective on a patient’s body condition and should be recorded in the medical record at every visit. Limitations of the BCS include the subjectivity inherent in the scoring system (Figure 2) and interobserver variation. Finally, like body weight, BCS gives an overall assessment of body condition; it cannot differentiate between body compartments and does not provide any precise quantitative information concerning alteration in fat free or lean body mass relative to fat mass.

**Morphometric measurements**

Height and circumferential measurements of the abdomen, hip, thigh and upper arm are commonly used to estimate percent body fat in humans. Circumferential measurements have also been developed to estimate the percent body fat in cats (8). The Feline Body Mass Index™ (FBMT™) is determined by measuring the rib cage circumference at the level of the 9th cranial rib (Figure 4) and the leg index measurement (LIM), which is the distance from the patella to the calcaneal tuber (Figure 3). The percent body fat can be calculated as 1.5 (ribcage - LIM)/9, or determined by consulting a reference chart (Figure 5). Cats with more than 30% body fat are candidates for a weight loss program. The FBMI™ is a very simple, yet objective tool to determine the body fat content of the cat. In addition, it is particularly valuable for convincing clients that their cat is indeed overweight and in need of weight loss. Pelvic

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**Figure 1.** Composition of the body.

**Figure 2.** Comparison between body condition score as assessed by one operator, and percent body fat determined by dual energy x-ray absorptiometry (DEXA) in 20 adult dogs. The subjectivity of the body condition score system is highlighted by the range of body condition scores assigned to dogs with similar percent body fat.

**Figure 3.** The length of the lower leg (LIM) from the middle of the patella.

**Figure 4.** Measurement of the rib cage circumference.
circumference and distance from hock to stifle has been shown to predict body fat in dogs (9).

The measurement of skin-fold thickness has been used extensively in people to determine the percent body fat using equations derived for various populations. This estimate is based on the relationship between thickness of subcutaneous fat layer and total body fat. Unfortunately, these measurements cannot be used in dogs and cats because canine and feline skin is easily detached from underlying fat tissue, which makes skin-fold measurement impractical and unreliable in these species.

Another method of measuring the subcutaneous fat layer is by ultrasound. This technique has been used experimentally in Beagles and equations have been derived to predict percent body fat from the subcutaneous fat thickness (10). These regression equations do not work in other dog breeds but future research may allow investigators to develop new, more accurate equations for this simple technique.

Dilutional techniques

Total body water (TBW)

Dilutional techniques rely on the principal of $C_1V_1 = C_2V_2$, that is, the volume of a biological fluid can be calculated following the administration and equilibration of a known concentration of tracer. The tracer administered should be non-toxic, non-metabolizable, and easy to administer, and have the same distribution volume as the fluid under investigation. The TBW method relies on the assumption that fat has negligible water content and the FFM has fairly constant and known water content (73%). FFM can be calculated as TBW/0.73 and since body weight = Fat + FFM, an estimation of body composition can be made.

Isotopes of hydrogen (deuterium ($D_2O$) and tritium ($^3H_2O$)), urea, alcohol, N-acetyl-4-aminopyrine and $H_2O^{18}$ distribute in the TBW compartment and have been employed to quantify TBW. The approach used in most laboratories is dilution of the stable isotopes $D_2O$ or $H_2O^{18}$. These techniques have been successfully completed in dogs (11, 12) and cats (13) and are appropriate for non-invasive studies, however they do require expensive analytical equipment. Deuterium and tritium undergo some exchange with non-aqueous H+ and hence can overestimate TBW by 3-5%. Similarly, $^{18}O$ will exchange with labile oxygen atoms and hence can overestimate TBW by 0-1%. Consideration also needs to be given to urinary and respiratory losses of isotope. TBW can be measured with a precision and accuracy of 1-2%. The potential concern with this technique is the assumption of the hydration factor, which may change with age, sex, species, breed or disease (14).

Extracellular fluid (ECF)

ECF is an important physiological component of total body water that can be altered in illness. ECF can be measured by use of compounds including inulin, $^{35}S_2O^{3-}$, $^{35}SO_4^{2-}$, SCN$, Br$, and $^{82}Br$ that distribute within the extracellular space. However ECF markers may not distribute uniformly in the sub-compartments of the ECF (plasma, interstitium, lymph, connective tissue), some markers penetrate cells to an extent that can not be precisely determined, or they may bind to some degree to endogenous components. Bromide is the most useful, safest, and widely used tracer for determination of ECW volume (15). Determination requires high performance liquid chromatography (HPLC) and correction factors can be applied to account for the Donnan equilibrium, serum water, and distribution in non-extracellular sites. Simultaneous measurement of ECF and TBW enables the estimation of intracellular water volume (ICW), i.e. ICW = TBW - ECW. ICW volume most closely approximates BCM.

Bioelectrical impedance analysis (BIA)

Bioelectrical impedance analysis is an electrical method of assessing body composition that has the potential of quantifying TBW, ECW, ICW, BCM, FFM and FM. Electrical conductance is used to calculate the composition of the body by measuring the nature of the conductance of an applied electrical current in the patient. Body fluids and electrolytes are responsible for conductance whilst cell membranes produce capacitance. Since adipose tissue is less hydrated than lean body tissues, more adipose tissue results in a smaller conducting volume or path for current and larger...
Techniques to Assess Body Composition

Impedance to Current Passage.

The FFM contains virtually all the water in the body and thus if bioelectrical impedance is measured, a value for FFM can be determined.

Two types of BIA systems are currently available; single frequency, which applies a 50 kHz current, and multi-frequency, which utilizes frequencies from 5 kHz to 1000 KHz. A BIA test is performed by placing four small electrodes on the body (Figure 6). The electrical current is introduced into the patient from the distal electrodes. As the current travels through the body, it experiences a slight delay due to cells, and the current is then detected by proximal electrodes. Low frequencies (e.g., 5 kHz) pass primarily through the ECW because of high cell membrane capacitance. In contrast, at higher frequencies, the effects of cell membrane capacitance are diminished so the current flows through both the ICF and ECF environments (or TBW). The proportion of the current in the ICF and ECF is frequency dependent (Figure 7).

BIA may be affected by hydration status, consumption of food and water, skin and air temperature, recent physical activity, conductance of the examination table, patient age, size, shape and posture in addition to electrode positioning. Reliable BIA requires standardization and control of these variables. BIA requires further evaluation and validation in disease states, especially those associated with major disturbances in water distribution and states such as sepsis, which may alter cell membrane capacitance. It has, however, been shown to be a safe, noninvasive, rapid, portable, and reproducible method to estimate body composition in healthy dogs, cats, and humans (16-19). Calculation of ECF-ICF takes approximately 1 minute, hence BIA provides instantaneous on-line information of body composition that has never before been available.

Dual energy X-ray absorptiometry

Dual-energy x-ray absorptiometry (DEXA) is a technique originally developed for precise measurement of bone mineral content (BMC). However, it is now also used to measure both body fat and non-bone lean tissue. DEXA uses photons of two different energy levels (70 and 140 kVp) to distinguish the type and amount of tissue scanned. The X-ray source is positioned underneath the table supporting the patient, with the detector housed in an arm above the patient (Figure 8). During a scan, the source and detector move together over the patient. The detector measures the amount of X-rays that pass through the subject. The X-rays of the two different energy levels are impeded differently by bone mineral, lipid and lean tissue. Algorithms are used to calculate both the quantity and type of tissue in each pixel scanned. DEXA calculates bone mineral density (BMD), bone mineral content (BMC), fat mass, and lean body mass.

DEXA's low coefficient of variation for measuring BMC (~1%) makes it a very precise technique. DEXA also is safe and quick, requiring 10-30 minutes for a whole body scan. Similar to other body composition techniques, DEXA relies on the assumption that lean body mass is uniformly hydrated at 0.73 mL water/g.

Figure 6.
Multi-frequency bioelectrical impedance analysis on a dog.

Figure 7.
Electrode placement and theory underlying multi-frequency bioelectrical impedance analysis. Low frequency current passes primarily through the extracellular fluid (ECF) whereas high frequency current flows through both the intracellular (ICF) and extracellular fluid environments.

Figure 8.
Dual-energy X-ray absorptiometry (DXA) prior to weight loss revealed body fat content of 42% (reference range 20 to 35%).
Techniques to Assess Body Composition

Summary
The ideal body composition method should be accurate, safe, inexpensive, rapid, reliable, highly reproducible, and easy to operate. Methods that have clinical application include body weight, body condition scoring, morphometric measurements, dilution studies, bioelectrical impedance analysis and dual energy x-ray absorptiometry. Regardless of the technique selected, it is imperative to meticulously follow established protocols to limit measurement error. The ability to accurately measure body fat and fat free mass (lean body mass) is vital for understanding the causes and effects of obesity. In addition, these techniques allow critical appraisal of the effect of nutrient composition on body composition.

REFERENCES
Clinical risks associated with obesity in companion animals

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Alex German qualified, with honors, from the University of Bristol (UK) in 1994. After two years in mixed practice he returned to Bristol to undertake a PhD in canine mucosal immunology, and then a residency in small animal internal medicine. He attained the RCVS certificate in small animal medicine in August 2001, and became a Diplomat of the European College of Veterinary Internal Medicine in September 2004. He is currently the Royal Canin Lecturer in Small Animal Medicine at the University of Liverpool, and also Director of the Royal Canin Weight Management Clinic, the UK’s first referral service for obesity biology. His research interests include all aspects of small animal internal medicine, gastroenterology, comparative obesity biology, and clinical metabolomics.

Introduction

Obesity is defined as an accumulation of excessive amounts of adipose tissue in the body (1), and has been defined as a greater than 15% increase above the ideal body weight for the individual. Obesity is an escalating global problem in humans, and current estimates suggest that almost two thirds of adults in the United States are overweight or obese. Studies, from various parts of the world, have estimated the incidence of obesity in the pet population to be between 22% and 40% (2). Most investigators agree that, as in humans, the incidence in the pet population is increasing. The most recently published data comes from a large study in Australia, where 33.5% of dogs were classed as overweight, whilst 7.6% were judged to be obese (2).

Obesity is known to be associated with increased risk of type II diabetes mellitus (DDMI), cancer, cardiac disease, hypertension, and decreased longevity. Similarly, obesity has detrimental effects on health and longevity of dogs and cats (Table 1), although data are more limited. Some studies do suggest an increase in morbidity in sick patients with poorer body condition in dogs (3). Evidence in cats also suggests increased health risks in obese individuals (4). This article will review the various clinical risks, which are known to be associated with obesity in companion animals, and also discuss the role that the adipose tissue itself plays in disease pathogenesis.

Clinical evaluation, physiology and anesthesia

Overall, clinical evaluation is more difficult in an obese patient compared with a patient in ideal body condition. Techniques that are complicated by...
obesity include physical examination, thoracic auscultation, palpation and aspiration of peripheral lymph nodes, abdominal palpation, blood sampling, cystocentesis, and diagnostic imaging (especially ultrasonography).

Anesthetic risk is also reportedly increased in obese companion animals and problems include estimation of anesthetic dose, catheter placement, and operating time. Finally, decreased heat tolerance and stamina have also been reported in obese animals.

**Longevity**

A recent prospective study has suggested the effect of obesity on longevity in dogs. Twenty-four pairs of Labrador retrievers (48 total) were used, and one dog in each pair was randomly assigned to one of two groups (5). The dogs in one group were fed *ad libitum*, whilst the dogs in the other group were fed 75% of the amount consumed by their respective pair. In the energy-restricted group, body condition score was closer to ‘optimal’ (e.g. group mean 4.5/9 (2.75/5)) than in the *ad lib* feeding group (e.g. group mean 6.8/9 (3.8/5)); lifespan was also increased (e.g. 13 years with energy restriction compared with 11.2 years when fed *ad lib*). Other beneficial effects included reduced risk of orthopedic disorders such as osteoarthritis, and improved glucose tolerance (5,6).

**Diseases associated with obesity**

**Endocrine and metabolic diseases**

A number of endocrinopathies are associated with obesity; in some cases obesity is the result of the disorder whilst, in others, the obesity predisposes to (or exacerbates) the endocrine disease. Hormonal diseases with a reported association with obesity include diabetes mellitus, hypothyroidism, hyperadrenocorticism (Figure 1), and insulinoma (1). Acromegaly can cause increased deposition of all soft tissue and is thus a differential diagnosis for obesity. However, in this condition, lean tissue and bone mineral are likely to be deposited in addition to adipose tissue.

**Insulin resistance, diabetes mellitus and the metabolic syndrome**

Insulin is secreted by pancreatic β-cells and it controls

![Figure 1](image-url)
uptake and use of glucose in peripheral tissues. In humans, tissues become less sensitive to insulin (i.e. become ‘insulin resistant’) with excessive caloric intake, and plasma concentrations of insulin increase in direct proportion to increasing BMI in both men and women. Thus, obesity, particularly abdominal obesity, is a major determinant of insulin resistance and hyperinsulinemia. Cats most often suffer from diabetes mellitus (DM) resembling ‘type II’ in man, and, similarly, obesity is a major risk factor in this species (7). Indeed, it has been experimentally proven that diabetic cats have significantly reduced sensitivity to insulin than cats without DM (8). In contrast, dogs more commonly suffer from DM resembling human type I DM. Therefore, although obesity is known to cause insulin resistance, there is no current data proving that obesity is actually a risk factor for DM in this species. As a result, obesity alone rarely leads to clinical signs (9).

**Hypothyroidism and thyroid function**

Although hypothyroidism is commonly cited as an underlying cause for obesity, such cases are the exception rather than the rule. The prevalence of hypothyroidism has been estimated at 0.2%, with under half of these dogs reported to be obese (10) whereas, in contrast, a much greater proportion of dogs (17-44%) is known to be obese (see above). Hypothyroidism is extremely rare in cats. Thus, whilst hypothyroidism should always be considered, it is rarely the reason for the obesity in most cases.

Obesity itself has a subtle, but likely clinically insignificant, effect on thyroid function (11); obese dogs were found to have higher concentrations of both total T4 and total T3 than non-obese controls, although such concentrations remained within the reference range and other parameters (e.g. free T4, thyroid stimulating hormone [cTSH], TSH stimulation test) were not significantly different. Further, weight loss caused significant decreases in total T3 and cTSH. Thus, although obesity and subsequent weight restriction may have some effects on energy balance and thyroid homeostasis, such changes are unlikely to affect the interpretation of thyroid function tests.

**Hyperlipidemia and dyslipidemia**

There are limited data in dogs with naturally occurring obesity, and most information has been derived from experimental studies. Published data suggest that lipid alterations can occur in obese dogs, with increases in cholesterol, triglycerides and phospholipids all noted, albeit often not exceeding the upper limit of the reference range (12-14). Making laboratory dogs obese by feeding a hyperenergetic diet has been shown to increase plasma non-esterified fatty acid and triglyceride concentrations by increasing concentrations of VLDL and HDL, whilst decreasing HDL cholesterol (13). Such changes were associated with insulin resistance and, interestingly, have also been described in insulin-resistant humans. Whether or not lipid alterations account for the increased incidence of pancreatitis in obese dogs requires further studies. Thus, further work will be required to assess further the significance of lipid abnormalities in dogs.

**Orthopedic disorders**

Obesity is a major risk factor for orthopedic diseases in companion animals, especially dogs. Increased incidence of both traumatic and degenerative orthopedic disorders have been reported (Figure 2), (15). One study reported body weight to be a predisposing factor in humeral condylar fractures, cranial cruciate ligament rupture, and intervertebral disc disease in Cocker Spaniels (16). Further, a number of

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**Figure 2.**

(a) 6 year-old neutered male Labrador with multi-limb lameness and obesity. On physical examination, the dog was greatly obese (body weight 54.5 kg, body condition score 5/5. (b) Lateral radiograph of the left elbow radiograph demonstrating osteoarthritis. (c) Ventrodorsal radiograph of the pelvis, demonstrating osteoarthritis of both hips, secondary to hip dysplasia. (d) DEXA prior to weight loss confirming body fat content of 42% (reference range 20 to 35%).
studies have highlighted the association between obesity and the development of osteoarthritis (6, 17), whilst weight reduction can lead to a substantial improvement in degree of lameness in dogs with hip osteoarthritis (Figure 2), (18).

Cardiorespiratory disease and hypertension
Obesity can have a profound effect on the function of the respiratory system (for example, see WSAVA abstract). Most notably, obesity is an important risk factor for development of tracheal collapse in small dogs (19). Obesity can exacerbate heatstroke in dogs, whilst other respiratory diseases that can be exacerbated by obesity include laryngeal paralysis and brachycephalic airway obstruction syndrome.

Obesity can also affect cardiac function; increased body weight can result in effects on cardiac rhythm, increase left ventricular volume, blood pressure and plasma volume. The effect of obesity on hypertension is controversial in the dog. One study suggested that obesity was significantly associated with hypertension, but its effect was only minor (20). In contrast, many experimental studies have utilized the obese dog as a model for the pathogenesis of hypertension and insulin resistance (21). Obesity may also be associated with portal vein thrombosis, and myocardial hypoxia.

Urinary tract and reproductive disorders
An association between obesity and some cases of urethral sphincter mechanism incompetence (USMI) has been reported (22). Obesity is not the only risk factor, with ovariohysterectomy itself also playing a major part. Nevertheless, the effect of obesity is clear in some dogs, which only become incontinent when they become obese. Conversely, weight reduction in overweight dogs with USMI can often be all that is required to allow continence to be restored. The reason for an association between USMI and obesity is not clear, although the effect may be purely mechanical e.g. increased retroperitoneal fat leading to caudal displacement of the bladder. The risk of developing calcium oxalate urolithiasis is also reported to be increased in obese dogs (23), whilst other urinary tract disorders may be exacerbated by obesity.

Obese animals are reported to suffer from increased risk of dystocia, likely related to excess adipose tissue in and around the birth canal (15).

Neoplasia
In humans, obesity is known to predispose to a number of different types of cancer; the International Agency for Research on Cancer has found there to be a significant link between obesity and cancers of the female breast (postmenopausal), colon/rectum, kidney (renal cell) and esophagus. It is estimated that if this link is entirely causal, being overweight or obese may account for one in seven cancer deaths in both men and women in the USA alone.

Breast cancer is the most common form of cancer among women worldwide. Obesity has consistently shown to increase rates of breast cancer in postmenopausal women by 30-50%. An association between mammary carcinoma and obesity has also been reported in some but not all canine reports. Overweight dogs have also reported to have an increased risk of developing transitional cell carcinoma of the bladder (24). However, a possible link between obesity and other companion animal cancers has not been explored fully.

Miscellaneous disorders
Obese animals have been reported to be at increased risk of certain dermatologic disorders. Diffuse scale is commonly observed (especially in cats), most likely due to reduced ability to groom efficiently. Animals that are severely obese can develop pressure sores (Figure 3). Decreased immune

Figure 3.
(a and b) 9 year old neutered male Siamese cat with gross obesity (body weight 12.95 kg, condition score 9/9 (5/5)). The obesity had led to inactivity, inability to groom and pressure sores on the ventral abdomen (c). (d) DEXA prior to weight loss confirmed body fat content of 54.4% (reference range 18 to 25%).
function has also been documented, with obese dogs being less resistant to the development of infections.

**Adipokines**

Adipokines are critical in the development of many obesity-associated disorders. The presence of excessive white adipose tissue (WAT) in obesity can predispose to the numerous disorders discussed above through a number of possible mechanisms. First, deposition of excessive fat can have ‘mechanical’ or ‘physical’ effects e.g. excessive weight bearing exacerbating orthopedic diseases, constriction of upper airways exacerbating respiratory disorders, inability to groom in dermatological complaints, and reduced heat dissipation due to the insulating effect of fat for heat stroke.

However, the perturbation of the normal endocrine function of WAT is now recognized as a major pathogenetic mechanism for the development and exacerbation of many of the obesity-associated disorders. Traditionally, WAT was thought of as a ‘passive’ organ, with few functions other than energy storage and insulation. However, more recently, WAT has been shown to be an active endocrine organ, secreting numerous factors, which can have a regulatory effect on many body systems. The endocrine functions of WAT are key to a number of normal physiological processes and, when WAT is present in excessive amounts in obese individuals, these normal processes can become disrupted.

The term ‘adipokine’ refers to a protein which is secreted from the adipocytes of WAT (25); some such factors have proven endocrine roles (e.g. leptin and adiponectin), whilst other may have autocrine and paracrine effects on adipose tissue itself (e.g. tumor necrosis factor alpha [TNF-α] and interleukin 6 [IL-6]). The adipokines include angiogenic factors (e.g. vascular endothelial growth factor), cytokines (e.g. IL-6), acute phase proteins (e.g. haptoglobin) and proteins involved in vascular hemostasis (e.g. plasminogen activator inhibitor-1; PAI-1), blood pressure regulation (e.g. angiotensinogen), the alternative complement system (e.g. adipsin) and lipid metabolism (e.g. cholesteryl ester transfer protein) (25, 26).

The diversity of the adipokines implies that WAT is widely involved in metabolic regulation, involving extensive communication with other organs. Increases in the production of several adipokines have been documented in human obesity, including leptin, TNF-α, IL-6, PAI-1 and haptoglobin (25, 26). The production of adiponectin, on the other hand, is decreased in the obese (27). Such changes in adipokine secretion in obesity may be causally related to the development of the metabolic syndrome and other disorders linked to the obese state.

**Adipokines and insulin resistance**

Circulating levels of several adipokines, such as haptoglobin and TNF-α, have been found to be raised in both diabetes mellitus and obesity (28).

**Adipokines, obesity and inflammation**

It has become generally accepted that obesity is associated with a state of chronic low-grade inflammation, and that this inflammatory state may be the link between obesity, DDMII and cardiovascular disease (25). In these states several markers of inflammation including acute phase proteins and cytokines such as TNF-α and IL-6, mainly thought to be of adipose tissue origin, are found to be elevated (25). The precise site of the inflammatory process, whether systemic or local, is still a matter of debate.

**Adipokines and hypertension**

White adipocytes are thought to be an important source of angiotensinogen (26), the substrate for renin in the renin-angiotensin aldosterone system (RAAS). This suggests that WAT plays an important role in blood pressure regulation. Indeed, it appears that apart from the liver, WAT may be the most important source of angiotensinogen (26). Importantly, circulating levels of angiotensinogen have been found to be raised in obesity. This suggests a direct link between hypertension and obesity (26).

**Adipokines and thrombosis**

Plasminogen activator inhibitor-1 (PAI-1) is important in the maintenance of vascular hemostasis, where it functions by inhibiting the activation of plasminogen, the precursor of plasmin, which is involved in the breakdown of fibrin (25). The expression and secretion of PAI-1 in both human and rodent adipocytes has been well documented (25). Visceral adipocytes are thought to be the main source of PAI-1 (29) indicating a strong link between visceral adiposity, PAI-1 levels and the increased incidence of atherothrombotic disorders frequently associated with visceral obesity.

**Summary**

Obesity is a growing concern in companion animals, and the increasing incidence appears to be mirroring the trend seen in humans. The main medical concern of obesity relates to the many diseases associations that accompany...
adiposity. Adipokines are thought to play a part in the pathogenesis of many obesity-associated disorders in man, and there are likely to be many parallels with companion animal disorders. There is a need both to increase the awareness of companion animal obesity as a serious medical concern within the veterinary profession, and to investigate more closely the pathogenetic basis of the various diseases associated with obesity.

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this initial reaction, some of us ponder the disturbance that led to the obesity we observe. Indeed, overeating appears to be the culprit in many cases, an example of which being the weight gain and in some cases obesity following neutering (1) (Figure 1).

However, diminished energy expenditure in the face of constant food intake also may cause undesired weight gain. This has been observed in spayed female cats when food intake is controlled to pre-spay levels (2). Decades of research on humans and animal models have led to the synthesis of many theories on the origin of obesity. Weakened satiety and enhanced feelings of hunger are perhaps the most intuitively obvious of causes for obesity.

### KEY POINTS
- The origin of obesity that we observe in dogs and cats is not well understood. This lack of understanding occurs in spite of reports that as many as 50% of dogs and cats are overweight in middle age.
- The overeating that we observe in dogs and cats probably has many causes and the variation in the degree of obesity that we observe may well reflect differences in cause for overeating.
- Although it might seem logical to prevent overeating by the management of factors that influence hunger, satiation, and satiety, it should be noted that disturbed satiation and satiety can lead to obesity, and obesity influences satiation and satiety in a manner that supports obesity.
- Agents that induce satiety may be one of several targets for which prospective medications may be developed. Other targets include anorectics, fat absorption inhibitors, thermogensics, and agents that partition energy away from adipose toward muscle.
- Perhaps the best way to manage satiety in the long run is to manage influential factors like obesity rather than to evoke extraordinary stimulation of satiety signals. By this way of thinking, weight loss should be undertaken first in the treatment of obesity.

### Introduction
When one encounters a conspicuously obese cat, it is perhaps a common reaction to blame gluttony and envision the cat flailing away in a pan of lasagna, a dish known as “nature’s perfect food” to Jim Davis’ Garfield the comic-strip cat. Once past
Other causes are more abstract and for humans are described categorically as sensorily-induced over-consumption, hedonistically-mediated maladaptive food choices, and errors in processes governing energy balance (3). The later cause of energy balance errors may be applicable to some breeds of dogs that are especially prone to obesity.

While causal theories abound, much to our disappointment, the origin of obesity that we observe in dogs and cats is not well understood. This lack of understanding occurs in spite of reports that as many as 50% of dogs and cats are overweight in middle age (4, 5).

**Overeating**

Past investigators have importantly noted that obesity occurs when palatable food is available in excess, and hard physical activity is not required. These conditions are becoming increasingly prevalent in the global population of humans, and they are likely experienced by their dog and cat companions. Given the recent global trend, it is not difficult to find grounds to speculate that obesity in companion animals results from a poor control of food intake in an environment of food abundance. In the case of cats, making food abundantly available is easy and commonly practiced with feeding of commercial dry-type (extruded) diets. Dry diets are often continuously presented whereas moist foods, such as the less energy dense commercial canned diets, are more often given intermittently.

At least in the United States, it is the commercial dry-type diets that appear most frequently consumed by obese cats (6). Reducing the availability of food by limiting exposure to diets reduces the risk for obesity (5) and effectively reduces body weight in obese cats (7) (Figure 2). In the case of dogs, more so than cats, continuous presentation of food rapidly leads to undesired weight gain. Temporal restriction of food as used in cats is not very effective in preventing obesity in dogs. As many dog owners can attest, dogs may consume their daily caloric needs in a very short time and then demonstrate poor food intake control with continued begging or display of other food seeking behavior.

Curiously, not all animals become obese when food is continuously present. It has been suggested that this heterogeneity reflects individual variation in elements contributing to the control of food intake, where the individual variation is not apparent until food is available in excess. The inquisitive among us may wonder about mechanisms underlying individual adiposity differences, and some of us may believe that understanding them will aid in the prevention and treatment of obesity. Unfortunately, complete understanding of why some animals overeat while others do not appears far-off. Over six decades of scientific investigation has revealed that the control of food intake is a complex process, comprised of many central and peripheral elements that are highly integrated and in some cases redundant in function. The central component, which is believed to be seat of the drive to eat (and probably overeat), is now seen as a composite of diffusely organized neuronal circuits spanning many brain regions. This view contrasts substantially with the once proposed food intake control model of anatomically distinct, hypothalamic centers that determine hunger and satiety. The structural and functional complexity now recognized in the control of food intake presents many possible sites where disturbances might act to cause overeating. Hence, the overeating that we observe in dogs and cats probably has many causes. The variation in the degree of obesity that we observe may well reflect differences in cause for overeating.

**Satiation and satiety**

For the purpose of presenting strategies to prevent overeating in cats and dogs, it is useful to consider food intake as a behavior rather than an outcome of a complex, incompletely understood physiological process. In this way, food intake can be described in terms as the amount of energy consumed, dietary pattern, or macronutrient profile. An example of this approach are studies of Kane and others (8) on feeding patterns in cats. When food in the form of a commercial dry-type diet is made continuously available, cats are found to eat many small meals each day (0 = 11 to 12), with a slight diurnal pattern of more meals in light than in dark periods.
When considering food intake as a behavior, one might infer that there are unique motivations behind the behavior. Animals probably have counterparts to the motivations experienced by humans that compel them to eat or not to eat. Hunger is a key motivation in human models of food intake. Hunger is defined as a biological drive impelling ingestion of food, and in humans, it is described as a distinct sensation. Hunger varies in strength, and its strength importantly determines when and how much to eat. With ingestion of food, hunger diminishes, and physiological processes that inhibit food intake are stimulated. With continued eating, a feeling of fullness develops so that eventually eating is terminated. Eating will not resume until the feeling of being full subsides, and hunger again develops. The increasing sensation of fullness developing during a meal is called “satiation”. Those who study food intake behavior distinguish satiation from satiety. Satiety is considered a motivation not to eat between episodes of eating. It is the state of satiety that delays the onset of a meal and may reduce the amount of food consumed in a forthcoming meal. Here, it is instructive to cite that “satiation” and “satiety” are defined by some investigators as intra- and inter-meal satiety, respectively.

In Figure 3, the timing of hunger and satiety in relation to food intake is illustrated against the meal-pattern observations in a cat by Kane and others (8). When considering this model, it is natural to speculate that overeating (expressed as increased meal size and or meal frequency) is caused by increased hunger, diminished satiation, or reduced satiety. In view of this model, a logical approach to prevention of overeating is management of factors that influence hunger, satiation, and satiety. Of such influential factors, diet and environment are well within the control of those who care for dogs and cats.

Blundell (3) has proposed that characteristics of food and physiological responses to the characteristics interact and determine the duration and strength of satiation and satiety (Figure 4). In this view, responses to food are categorized as sensory, cognitive, post-ingestive, and post-absorptive. Food characteristics that serve as stimuli include volume, weight, energy content, energy density, and macronutrient proportion. Although developed for humans, Blundell’s model appears suitable for evaluating factors important for the management of satiety in dogs and cats. Perhaps a good factor to first consider in this model is dietary fat. For cats, when the weight percentage of fat in a purified diet is increased from 15 to 45 % (4.8 to 6.2 kcal/g, respectively), meal size decreases while meal frequency is not significantly changed (Figure 5). Meal size in this case decreases to the extent that energy intake is not significantly affected. It may be that sensitivity to sensory input important in satiation increases to the extent that a body energy imbalance does not occur. A heightened sensitivity to the volume and weight of the high-fat diet might have developed as a conditioned response. On the other hand, if meal frequency were found to be decreased in cats given the high-fat diet, then it might be suggested that sensitivity to post-ingestive and pre-absorptive inputs are increased, and satiety is appropriately prolonged. Unfortunately, this response of cats to a high-fat purified diet does not seem to be congruous with what is typically observed for commercial diets.
Anecdotal accounts and an epidemiological study indicate that increasing fat in commercial dry-type diets increases the risk of obesity (6).

In considering Blundell’s model, many causes for a varying effect of fat on food intake can be offered. For example, the sensory response to the greater palatability of a commercial relative to a purified diet may prolong the satiation phase. Unfortunately, effects of dietary factors on meal patterns in cats and dogs appear to be rarely reported. Future study of how dietary fat affects meal patterns in cats given commercial dry-type diets may be useful in sorting out fat’s effect on satiation and satiety. If a dietary factor is found to attenuate satiation, then overeating might be best prevented by control of food portions. Whereas, if a dietary factor is found to reduce satiety, then decreasing the period of dietary exposure might be more convenient than portion control for preventing overeating.

**Dietary macronutrients**

It is pertinent to point out that dietary components differently engage processes mediating satiation and satiety. Dietary protein is generally believed to exert a potent effect on satiety (10). Relative to protein, dietary carbohydrate and fat are less inhibitory of food intake, and between carbohydrate and fat, fat appears to be the least potent in affecting food intake. The basis of protein’s potency is unknown. Its effect appears to occur above dietary protein requirement levels, a condition that would seem consistent with a regulation of dietary protein intake (11). Some essential amino acids when ingested in excess of their requirement are believed to produce physiological stress in proportion to their toxicity. As physiological stress is known to alter feeding behavior, herein may be a mechanism for the increasing inhibition of food intake with increasing dietary protein.

Cats appear to deviate from other species in their susceptibility to protein’s potent effect on satiety. Purified diet studies show that cats do not have a strong metabolic cue to consume a particular “optimal” level of protein (12). A diet as high as 63 % (wt/wt) in soy-protein is consumed in amounts similar to a diet containing moderate (31 %) and near-requirement levels (16 %) of protein. Cats may not even discriminate against eating a diet lacking in protein when given an equally palatable diet that contains protein. This uniqueness of cats would appear to preclude using dietary protein concentration as a means to manage satiety in cats. However, it is important to note that dietary protein sources vary in their palatabilities. A relevant example is casein. Because casein is not especially palatable to cats and to some other species, increasing its concentration in a diet is found to reduce food intake (12).

Most studies show that dietary fat has a weaker effect on satiation and satiety than dietary carbohydrate (10). For many species, increasing the concentration of dietary fat results in an increase in the amount of adipose mass maintained. The weak satiating potency of dietary fat is consistent with this observation. Relative to carbohydrate, absorption and metabolism is slower with fat. The delay in sensing a fat load may attenuate fat’s satiation potency and more easily permit over-consumption of calories from fat than carbohydrate. Slight over-consumption of fat may further weaken satiating potency of dietary fat if body fat mass is expanded. This effect of dietary fat is indicated in a recent study of brain insulin transport in dogs made obese by feeding a high-fat diet (13). While insulin is well known for its role in metabolism, insulin also negatively feeds back on food intake. With obesity, insulin transport to the brain is impaired. A not so surprising application of these findings is that feeding of diets high in fat should be avoided for management of satiety. An interesting enigma worthy of note is that feline commercial canned diets are typically high in fat, but obesity is not typically associated with canned diet feeding. One explanation for this paradox is that the palatability of canned diets rapidly diminishes with exposure to ambient conditions, and therefore meal frequency may be unintentionally reduced. Another explanation is that overeating may be precluded by the large caloric dilution with water in canned diets.

While satiety has a clear definition as applied by behaviorist, its definition is not as clear in all applications. Physiological responses to food that contribute to meal-termination or those that facilitate further inhibition of food intake are called “satiety signals”. Such signals could exert their effect by decreasing the drive to eat (hunger) or increasing the feeling of being full during or between meals (satiation and satiety, respectively). Overriding satiety signals that arise from the volume of food consumed (e. g., from gastric distension) may explain the obesity resistance found with feeding high-moisture, canned diets to cats. Diets made high enough in metabolically inert material such as water and some dietary fibers might protect against overeating by a common means. In the case of fiber, effects on satiation and satiety in dogs and cats have not been well described. High fiber diet presentation for ad libitum consumption reportedly can promote weight loss in dogs (14) and cats (15).
However, some investigators find no specific satiety value of dietary fiber in energy restricted dogs given calorically dilute (~ 0.5 kcal/gram of feed), high moisture (> 80 %) diets (16). Future study might demonstrate significant satiation and satiety benefits from dietary fiber. However, it may not be useful because of secondary problems of constipation, unacceptable excessive fecal output, and decreased palatability and nutrient digestibilities.

**Transient potency of satiety signals**

Another point to consider with dietary fiber and other interventions used to manage satiety is the redundancy of feedback inputs in food intake control. There are many satiety signals and each provides information on one or more attributes of food. A particular satiety signal may lose its potency in suppressing food intake when its importance to energy balance is learned to be inconsequential. Such learning about satiety signals is apparent in the ability of an animal to appropriately decrease or increase their food intake with a changing energy density of food. Therefore, in some cases, effects of a dietary manipulation on satiation and satiety may be fleeting, and in the long run they might not prevent the overeating that leads to undesired weight gain.

When presented with a variety of foods, there is a well-described tendency for animals to consume more than just their preferred food (17). This behavior is believed to be resultant of satiety being specific to sensory properties of a food being ingested, such as, taste, odor, and texture. When given a choice of foods, an initially preferred food may become less appealing while a lesser preferred food becomes increasingly attractive. A consequence of this phenomenon is that food intake is enhanced (and probably inappropriately) by increasing the types of foods made available for consumption. Such “sensory-specific satiety” may in part explain why obesity is associated with the feeding of treats, which often varying their sensory properties. Therefore, for the purpose of managing satiety, food variety should be limited and treats might best provided as portions of the maintenance diet.

**Non-dietary manipulations**

Control of food intake is interconnected with several other biological systems. This integration is a means by which factors unintuitively related to food intake influence satiation and satiety. An example is the increase in meal size typically observed in animals previously deprived of food. Satiation in this case is influenced by the state of energy balance. In human obesity, meal size rather than meal frequency is greater than it should be for maintenance of a healthy body condition. Hence, in obesity, satiation appears altered so that an abnormally large adipose mass is defended. A similar condition probably occurs in dogs because food presentation in most obese dogs is controlled (albeit insufficiently), thereby eliminating the variable of meal frequency. However, this condition is not a certainty because obese dogs often receive treats throughout the day, and their interest in treats may reflect diminished satiety. To my knowledge, it has not been reported whether obese relative to lean cats have larger meals or more frequently visit the food bowl. In any case, satiation and satiety appear negatively influenced by obesity in companion animals (e.g., the food intake differences found between overweight neutered and lean intact cats, Figure 6). This influence of obesity presents a uniquely difficult problem to solve. Disturbed satiation and satiety can lead to obesity, and obesity influences satiation and satiety in a manner that supports obesity. Perhaps the best way to manage satiety in the long run is to manage influential factors like obesity rather than to evoke extraordinary stimulation of satiety signals. By this way of thinking, weight loss should be undertaken first in the treatment of obesity. Then, once body weight is normalized, future weight gain may be prevented by measures increasing satiation and satiety, such as, feeding diets low in calories, low in fat and or high in protein.

Early studies of food intake control brought to light that many areas of the brain may influence food intake in dogs and cats (18). Facilitation and inhibition of feeding by the limbic system are especially important findings of this early work. Buffington (19) recently has suggested that obesity risk is in part determined by how an animal reacts to its environment. His thesis, which is developed...
for cats, is based on observations of high obesity risk for animals that are inactive and living indoors – suggested unnatural and stressful conditions to some animals. How environmental variables (of which there are many) might affect satiation and satiety in companion animals has not been described. Manipulation of environmental variables to reduce stress that is done in treatments of many chronic diseases may be beneficial for satiety management. Suggested effective measures are changes in feeding practices, available space, opportunities for play, environment enrichment, and interactions with humans and other animals (19).

The current treatment of choice for obesity in dogs and cats is food restriction with manipulations to increase physical activity. This treatment often fails because of poor owner compliance in the face of displays of hunger and or weakened satiety. The lacking success of obesity treatment has spawned interest in pharmaceutical solutions. Unfortunately, little data are available on pharmacological approaches to obesity in companion animals (20). Past pharmacotherapies generally have been unsuitable for humans and companion animals because of significant side effects and poor risk-benefit ratios. Recent rapid expansion in knowledge of food intake control has given rise to speculation that effective and safe pharmacological treatments of obesity may be realized in the future. Agents that induce satiety may be one of several targets for which prospective medications may be developed. Other targets include anorectics, fat absorption inhibitors, thermogenics, and agents that partition energy away from adipose toward muscle. Future satiety inducers could be satiety signal mimics or agonists and antagonists of receptors in satiety pathways, such as those involving cholecystokinin (CCK), glucagon-like peptide (GLP-1), ghrelin, and peptide YY (YY). It should be appreciated that potential human applications drive research for obesity pharmaceuticals. While progress may occur here, corresponding applications for dogs and cats should not be assumed. Less effectiveness and side-effects that are more severe or unique are reported in dogs and cats for agents developed for humans.

**Conclusions**

Because obesity appears to sustain the drive to overeat, satiety management is probably best used for prevention rather than treatment of obesity. Measures, which enhance satiety, are the feeding of diets low in fat and low in energy density, where energy density may be decreased by caloric dilution with water or fiber. Diets containing protein in excess of concentrations needed to meet an animal’s requirement for protein may be useful for managing satiety in dogs, but not cats.

Whether by dietary or pharmacological means, exploitation of satiety signals to enhance satiation or satiety may be effective only transiently. This is because “learning” occurs in the control of the food intake. The satiation potency of food characteristics such as volume, weight, taste, and texture is not static but dynamic. Little is reported about how meal patterns in dogs and cats are affected by dietary and environmental factors. Future research may reveal that satiation and satiety can be beneficially manipulated to prevent overeating with safe and effective pharmacological agents or environmental changes that reduce stress.

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Nutritional aspects of obesity

Introduction
Obesity is not just an excess of body weight; it is a serious disease due to the many accompanying disorders that it may induce.

The majority of owners of obese animals do not spontaneously seek veterinary advice to resolve the problem of excess weight. As a rule, they are not fully aware of the condition of their animal and it is therefore up to the practitioner to make the diagnosis, and convince the owners of the seriousness of the condition and motivate them to undertake a diet.

The secondary disorders, exercise intolerance, joint disease, cardiovascular disease etc., are often delayed in comparison with the onset of obesity, but the owners must be convinced as early as possible that excess weight is not just an aesthetic problem, and that it requires vigorous and rigorous correction.

Obesity: preliminary steps when preparing a feeding program
Initial general clinical examination
This first consultation is the perfect opportunity to take stock of the animal’s general status and the owner’s motive for the consultation. It is important to establish the severity of the problems detected by the owner and list those that have yet to become apparent. A detailed history should be taken of any previous medication, especially those that could affect energy metabolism, such as corticosteroids or progestagens. Behavioral factors should also be taken into account, such as the temperament of the animal and level of activity, which is usually reduced in proportion to the excess body weight. Management and lifestyle issues such as living conditions and context, opportunity to increase energy expenditure, cohabitation with other animals are also important to identify.

Win over the owner’s conviction and cooperation
As mentioned previously, it is often difficult to get an owner to admit that their animal is obese, especially if the obesity has not yet caused any clinical problems. Additional time is needed during obesity consultations for the veterinarian to convince the owner. It is useless to undertake such a consultation if it is clear that the owner does not wish to comply or if you do not have adequate time. Different approaches may be envisaged but it is often preferable to use positive messages (explain all the advantages of weight loss for the dog’s health: animal in better health, more alert, longer life) rather than negative (deleterious effects of obesity, associated diseases). One should adapt to the owner, concentrate on the arguments that are most likely to affect them (longevity, responsibility towards the animal’s health), and the arguments that are directly related to the animal (improvement of the clinical signs).

To conclude the initial consultation, one should:
• Agree with the owner on a target weight. The most important thing is to get them to admit the necessity for weight loss and the diet and that the latter will be effective. It is often only after the initial results that it becomes possible to refine the prognosis and the objectives.
• Set a clear goal: “your dog must therefore lose this many kilograms in so many months”, is more likely to convince the client than “your dog is too fat; we are going to put him on a diet to get him to lose weight”.
• Warn the owner that it is difficult (physiologically), trying (emotionally), and a slow process to make an animal lose weight, and that they will therefore need determination and perseverance. Asking them to weigh the animal once a week...
throughout the period of the diet to monitor the results can be a way of encouraging them, but it is above all a way of involving the owner and making them more rigorous.

**Dietary history**

An in-depth dietary history should enable evaluation of the animal’s energy consumption at the time of consultation. Remember that many owners will state that their pet eats very little, and, even if this is not the case, it often the owner’s impression. One must not lose sight of the fact that the principal determining factor for energy expenditure, in a relatively inactive animal, is its lean mass. Indeed, even when adipose tissue represents 50% of the animal’s weight (a "normal" value would be around 15%), it would only be responsible for around 10% of energy expenditure. Thus, the more obese the animal, the less it needs to eat with respect to its weight, and this is even more marked the more inactive it is. The initial dietary inventory should therefore enable an estimation of the level of calorie expenditure (equal to ingested energy if the weight is stable) and, secondly, to ensure, when applying one of the levels of restriction presented below, that the prescribed energy ration is not greater than that usually ingested by the animal.

**In extremely obese animals whose energy expenditure, when their weight is stable, is generally very low, one should ensure that the quantities of energy provided by the diet are lower than those that the dog usually consumes.**

The discussion should be based on several general points, notably the animal’s environment (context and lifestyle, presence of other animals), and its mode of feeding. One should find out who feeds the animal and whether several different people are involved. One needs to find out what the animal usually eats (brand, type of product), and how much (method of feeding: ad-lib or restricted quantity), and whether the animal also receives treats or table scraps, etc.

If the current dietary situation cannot be established with precision, one can try to obtain information over a period of observation. The owner should be asked to continue as normal (which is obviously illusory) and make a note of everything that the animal eats (what, when, how, how much?) and who feeds it for two or three weeks (the time needed to obtain the results of complementary examinations) including titbits and treats. At a second consultation at the end of this period, the situation can be assessed and a prescription can be issued that is as perfectly reasoned as possible.

**Obesity: the degree of energy restriction**

Once the owner is convinced that weight loss and calorie restriction are imperative, all that remains is to establish a forecast of weight loss and to determine the most appropriate diet for the circumstances and the objectives.

**A standard level of restriction?**

Different programs have been proposed, often independently of all reference to the excess weight or to the level of feeding at the time of consultation. The most commonly prescribed of these diets only covers 60% (thus a restriction of 40%) of the energy requirements calculated on the basis of the objective weight of the animal.

A review of the various studies published shows that resulting weight loss can vary considerably. Thus, by applying a 40% restriction in energy intake (i.e. by providing 60% of requirements) in dogs, we have observed a weight loss of between 12 and 26% of the initial weight depending on the individual case, over a period of between 7 and 16 weeks (1, 2), which represents a weekly weight loss of 0.72 to 4.26%. Similarly, by applying a 60% restriction in energy intake (providing 40% of requirements) for 12 weeks, the resulting weight loss ranged from 4.8 to 27.8% of the initial weight (3). Finally, in another study applying a 50% restriction, it took between 40 and 161 days to achieve the ideal weight (4). Results obtained with obese cats were just as conclusive and equally variable. A 40% restriction thus gave a weight loss of 2.4 to 17.1% in 14 weeks (5), whilst a restriction of between 25 and 50% was needed to induce a mean weekly loss of around 1.5% (6).

**These figures show the extreme variability of results obtained for similar levels of energy restriction and reciprocally that the same objective can be attained using different degrees of restriction. The latter is principally dependent on the extent and origin of the obesity, and to the amount previously consumed.**

**A reasoned level of restriction**

The choice of the degree of energy rationing should be adapted as a function of several criteria, notably to the degree of excess weight (and thus the target weight loss), the sex of the animal, and the planned duration of the diet. In a recent experimental study in Beagles, it became apparent that it was harder to induce and maintain weight loss in obese females, whether intact or neutered, than in sterilized males.

One could therefore be tempted to apply a severe energy restriction to limit the duration of the diet. This is not recommended. Indeed, overly severe restriction may cause:
• A significant sensation of hunger in the animal generating increased activity before mealtimes and discourage the owner
• Excessive lean tissue loss (muscle mass)
• A rebound effect: during the weight loss period, basal energy expenditure decreases (resistance to weight loss) and, during the subsequent period of normal feeding, remains inferior to that of lean animals of the same weight, thus facilitating weight gain after the diet
• A more marked decrease in physical activity, which constitutes a second risk factor for reduction of muscle mass

It is apparent from the various published experimental and clinical studies that a reasonable objective is to maintain a loss of 1 to 1.5% of initial weight (obese) per week, equivalent to a loss of 6 to 7.5% per month. Table 1 indicates varying degrees of energy restriction as a function of several parameters: excess weight, male or female, neutered or intact, breed, and clinical examination.

These figures remind us, as if that were necessary, that a systematic restriction of 40% is a very crude approach, with correspondingly varied results.

The approach is exactly the same for cats (Table 2). However, we do not have as much information available, notably in terms of any possible male-female differences. Given that neutering is more and more common in both sexes, the proposed ration is not differentiated. Moreover, given the inherent risks of rapid weight loss, and notably the very real risk of hepatic lipodosis in the event of anorexia, even if it is not total, a weight loss of no more than 1.5% of the initial weight per week should be envisaged. In the most obese animals (those with a maximal body condition score, regardless of the type of scoring system used, 5, 7, or 9 point scale), the recommended calculated energy allocation is very low and may need to be slightly increased, which obviously means prolonging the probable duration of weight loss.

What weight loss should be anticipated?

Table 1 also shows that, if the initial excess is 40%, a weight loss of 2% per week should enable the objective to be attained in around 17 weeks. If it is 30%, 15 weeks should be sufficient at a rate of 1.75% per week, and if it is 20%, 12 weeks at an average loss of 1.5% per week (Figure 1).

If a client brings in a 30kg dog whose ideal weight is 23kg, and in which we want to achieve a weight loss of 5kg (target weight = optimal weight = 25 kg), these 5kg represent between 35,000 and 40,000 kcal that the animal must mobilize. If we want it to lose these 5kg in 6 months, the energy intake will have to be reduced (that calculated on the basis of maintaining the target weight) by a minimum of 200 kcal per day. Increasing physical exercise whenever possible enables an increase in energy expenditure, accelerates weight loss and decreases the resistance to weight loss.

Finally, we should underline the fact that the most important point is that the energy intake be effectively (and not "theoretically") reduced, i.e. less than what the animal was receiving previously. The dietary history is made even more important by the fact that for the same body weight, an obese animal often eats less than a lean subject. If sufficiently precise information is not available and a standardized restriction is applied, the owner should be informed that anything should be expected, even weight gain, and the next check-up should be booked (one month later) for a probable if not inevitable adjustment.

---

Table 1. Energy intake recommendations for weight-loss programs in the dog

<table>
<thead>
<tr>
<th>Excess weight</th>
<th>20-30%</th>
<th>30-40%</th>
<th>&gt; 40%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body condition score (BCS)</td>
<td>25-35%</td>
<td>35-45%</td>
<td>&gt;45%</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Daily energy intake (kcal ME/kg TBW°°)</th>
<th>male</th>
<th>female</th>
<th>male</th>
<th>female</th>
<th>male</th>
<th>female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss of 6% of initial weight per month (around -1.5% per week)</td>
<td>85</td>
<td>75</td>
<td>75</td>
<td>65</td>
<td>60</td>
<td>55</td>
</tr>
<tr>
<td>Probable duration of weight loss</td>
<td>15-18 weeks</td>
<td>18-20 weeks</td>
<td>≥ 20-22 weeks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily Energy intake (kcal ME/kg TBW°°)</td>
<td>male</td>
<td>female</td>
<td>male</td>
<td>female</td>
<td>male</td>
<td>female</td>
</tr>
<tr>
<td>Loss of 7.5% of initial weight per month (around -2.0% per week)</td>
<td>80</td>
<td>75</td>
<td>65</td>
<td>60</td>
<td>55</td>
<td>50</td>
</tr>
<tr>
<td>Probable duration of weight loss</td>
<td>9-11 weeks</td>
<td>11-13 weeks</td>
<td>≥ 15-17 weeks</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Nutritional aspects of obesity

Obesity: a logical approach to formulating a ration

It is totally contraindicated to restrict the intake by simply restricting the quantity of food usually consumed. This option leads to nutritional deficiencies and is unlikely to be successful. The formulas therefore need to be adjusted, both in terms of energy and nutrients (proteins, essential fatty acids, minerals, vitamins) as well as in terms of “volume” (fiber). Finally, one can envisage the use of molecules or specific ingredients that could improve the slimming potential of the feed.

Adjustment of the protein-calorie ratio (PCR)

In the context of weight loss, the protein-calorie ratio (PCR), expressed in grams of proteins per mega calorie of metabolizable energy (g/kcal ME), should be greatly increased in comparison with the recommended maintenance value. The rationale for the increase in PCR can be justified on physiological and mathematical grounds and exploits the properties and advantages of protein.

An essential adjustment

The protein concentration of diets destined for the nutritional treatment of obesity should, to cover the requirements in essential amino acids or not, be well above those of rations recommended for maintenance. Since the energy intake is greatly reduced, the protein concentration (PCR) must be increased in inverse proportion to prevent reducing protein intake (grams per day) below physiological requirement. An animal’s protein requirements are essentially determined by its lean mass and are therefore, in first approximation, linked to its ideal weight (the fat mass only contributes to around 5% of energy expenditure, and has an almost negligible contribution to nitrogenous expenditure).

The protein intake should also be increased when significant quantities of dietary fiber are incorporated, due to the decreased digestibility that the latter provokes. The same reasoning also applies, on both these fronts, for all essential nutrients.

The advantages of protein

High protein diets have been used with great success for many years in man and have, other than the physiological imperative explained above, demonstrated numerous advantages:

- Decreased net energy return compared to carbohydrates and lipids
- A positive effect on body composition whilst preserving lean tissue mass: diets with a high protein content make it possible to increase the loss of fatty mass and to minimize the loss of lean tissue
- Food rich in proteins provides greater satiety than food rich in carbohydrates or lipids
- A beneficial effect on satiety, which compensates (more or less) for the decreased levels of lipids and the increased fiber content;
- Improved preservation of weight loss after an ideal weight is attained and the diet is suspended

It is therefore imperative to significantly increase the PCR of the food, provided that renal function is normal.

Although it has been demonstrated that the speed of weight loss is also a determining factor (7), it has also been demonstrated that the higher the PCR, the lower the loss of lean mass, for an identical weight loss (8).

Dietary fiber

The incorporation of fiber, whether more or less soluble, is not uniform in low energy diets but is nonetheless one of the primary means of decreasing the energy density of feeds and thus ensuring a satisfactory volume for a reduced energy content.

In the dog, energy restriction obtained by administering a diet with high fiber content but also low lipid content has enabled a greater reduction in body fat and serum cholesterol concentrations (9). In general, the majority of studies available suggest that fiber is beneficial in the diet of obese patients: It affects satiety and digestibility. Increasing fiber has advantages and disadvantages, in addition to some, albeit small, energy value:

Table 2. Energy intake recommendations for weight-loss programs in neutered cats

<table>
<thead>
<tr>
<th>Excess weight</th>
<th>% body fat</th>
<th>Daily energy intake (kcal ME/kg TW)</th>
<th>Body condition score (BCS)</th>
<th>Probable duration of weight-loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-30%</td>
<td>25-35%</td>
<td>30</td>
<td>4</td>
<td>15-18 weeks</td>
</tr>
<tr>
<td>30-40%</td>
<td>35-45%</td>
<td>25</td>
<td>4.5</td>
<td>18-20 weeks</td>
</tr>
<tr>
<td>&gt; 40%</td>
<td>&gt; 45%</td>
<td>20</td>
<td>5</td>
<td>22-22 weeks</td>
</tr>
</tbody>
</table>

Figure 1. Examples of decreasing weight graphs for a Beagle with an amount of excess weight of 20% (initial weight: 16.8 kg, optimal target weight: 14 kg). Ideally, the goal should be to achieve 2% body weight loss per week.
Some advantages of increasing fiber in the diet:
• In the dog, although it is harder to evaluate the sensation of satiety than in man, diets with high levels of fiber seem to improve satiety (10).
• Fiber increases the volume of intestinal chyme, thus diluting enzymes and the constituents of micelles. It can adsorb enzymes, bile salts and phospholipids. All of which slows the solubilization of the constituents of the food, their digestion and their absorption, thus decreasing their digestibility.

Some disadvantages of increasing fiber in the diet:
• An increase in the quantity of feces and the frequency of defecation.
• A decrease in the digestibility of certain nutrients such as proteins and minerals.
• The inherent energy value of fermentable fiber is poorly understood in carnivores but is estimated at around 1-2 kcal ME/g in man. This lack of information makes it difficult to define an optimal concentration.
• Despite controversy over the hunger-satisfying properties of dietary fiber, increasing the fiber content of food would seem to be a good way of reducing its energy density whilst maintaining an acceptable volume, if not for the animal (satiety?) then for the owner.

Nevertheless, their negative effect on the digestibility of certain essential elements should be taken into account (by increasing their concentration), as well as the possible and non-negligible energy value of fermentable fiber.

Other adjustments

Lipids
The lipid content of low energy foods should obviously be reduced due to their high energy density. Nevertheless, it is also quite clear that a minimum content is necessary to cover essential fat acid requirements and enable the absorption of fat soluble vitamins. The most recent recommendations are for a minimum of 15g/kcal ME (around 5% for a feed containing 3,300 kcal ME/kg). It is almost imperative to significantly reduce the fat content of diets.

Assimilable carbohydrates
Once the protein, fiber, and fat content have been adjusted, it is not difficult to deduce the place reserved for assimilable carbohydrates. Their nature is more important than their quantity, which is of little interest. The notion of the glycemic index was developed as a means of predicting the glycemic response following the ingestion of carbohydrates and is used when formulating diets for diabetics and, to a lesser extent, low-energy diets. A low glycemic index also generally signifies a decreased insulin response, favorable to the mobilization of fats.

Other nutrients
The vitamin and mineral content should be increased in proportion with the energy restriction if their concentration is not to be too low, particularly if dietary fiber is increased.

As for protein, the vitamin, mineral, and trace element content of low-energy diets should be increased compared to that of maintenance diets. Restricting the energy intake should not result in deficiencies.

Specific ingredients and nutraceuticals
Certain specific ingredients, notably those influencing lipid metabolism and, beyond that, the body composition, may be incorporated into low-energy diets. Here we have cited only three, which are of current interest:
• L-carnitine improves nitrogenous retention and modifies the body composition in favor of lean body mass (11). It can therefore be recommended for obese animals on a low-energy diet, as well as later to prevent a subsequent rebound effect.
• The two conjugated fatty acids derived from linoleic acid, known as CLA (conjugated linoleic acids) could exert an anti-adipogenic action (12); a positive effect on the body composition has been demonstrated in the dog.
• Extracts of Garcinia Cambodica, whose principle actives are AHA (alpha hydroxy-citric acids), inhibit hepatic lipogenesis (13). Several clinical studies carried out in obese patients have yielded contradictory results.

Practical approach

Some habits have to be changed
Various epidemiological studies have demonstrated a number of risk factors for obesity in animals’ lifestyles (refer to Alex German’s paper in this issue).

The diet must be changed
As we have indicated, the choice of diet will first take into account its objective (the treatment of obesity), and possibly the speed of the planned weight loss. The diet should have an appropriate protein-calorie ratio, whose energy value (largely determined by the dietary fiber content) will be as low as possible whilst enabling an acceptable feeding ration and volume for the owner that is sufficiently filling (even if it is only short term) for the animal.

Dividing the daily ration into 3 or 4 small meals could increase postprandial thermogenesis. It is also a good
way of reducing the length of time that the animals go hungry thus limiting hyperactivity at mealtimes.

A home prepared ration is also theoretically possible, even though it is always more difficult to guarantee a balanced diet, if only due to the risk of variation of the quality of the ingredients or the ways in which they are prepared.

A follow-up is essential

Drawing up a weight loss curve enables the owner to visualize the progress obtained. It is usually a good motivating factor. When drawing up the program, an individualized weight loss curve is established with the initial weight of the animal and two curves corresponding to a weight-loss of 1 and 2% per week, the owner’s objective being to maintain the weight of their animal between these two curves. They should then be asked to weigh their animal once weekly, always under the same conditions (in the morning before the first feed for example) and, obviously, using the same set of scales.

It is also a good idea to ask the owner of an obese animal to come back for a check-up every 4-6 weeks to carry out a clinical examination, assess the behavioral aspects and adjust the feeding program (type and quantity) where necessary.

Good communication with the owner is vital

Firstly, they should be reminded that given the owner's objective being to maintain the weight of their animal between these two curves. They should then be asked to weigh their animal once weekly, always under the same conditions (in the morning before the first feed for example) and, obviously, using the same set of scales.

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Correct communication is often the guarantor of success.

Conclusion

In conclusion, we should remember the following major principles that generally guarantee the success of a nutritional treatment program for obesity in pets:

• Evaluate the previous diet
• Evaluate its body condition score
• Stress the clinical benefits of weight loss to the owner
• Determine a level of rationing: as a function of current food intake, the breed, age, sex etc. and the weight, the initial weight and the target weight
• Use a specifically formulated low-calorie weight loss diet
• Carefully weigh out the quantity of food perhaps dividing into three to four meals
• Set a realistic time frame and encourage the owner to persevere
• If weight loss is less than 1% or more than 3% weight loss per week, readjust energy intake accordingly
• Suggest, whenever possible, increasing the level of physical activity.

REFERENCES

The combination of data on stature and on body weight introduces the concept of morphometric techniques to evaluate body composition. Morphometry measures the outer form, evaluates certain body regions and how their dimensions change and shows their relationship to the modifications in the body composition. The morphometric techniques used on dogs are body condition scoring and techniques that combine diverse body parameter measurements (length and circumference of various parts of the body).

The body index is a semi-quantitative subjective evaluation method combining the evaluation of visible characteristics and a palpation of certain regions of the body. This evaluation is conducted in accordance with simple criteria: the size and location of major adipose deposits, the visible and invisible skeletal structure, and the silhouette of the animal.

Several types of index have been proposed:

- 3 grades: 1 = slim, 2 = optimal, 3 = excessive
- 5 grades: 1 = gaunt, 2 = slim, 3 = optimal, 4 = overweight, 5 = obese (Edney & Smith, 1986) (Tables 1 & 2)
- and even 9 grades: 1-4 = emaciated to slim; 5 = optimal; 6-9 increasingly overweight (Laflamme, 1993; Laflamme et al, 1994).

### Table 1. Body condition scoring in cats

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
</table>
| **Emaciated** | - Ribcage, spine, shoulder blades and pelvis easily visible (short hair)  
- Obvious loss of muscle mass  
- No palpable fat on rib cage |
| **Thin** | - Ribcage, spine, shoulder blades and pelvis visible  
- Obvious abdominal tuck (waist)  
- Minimal abdominal fat |
| **Ideal** | - Ribcage, spine not visible but easily palpable  
- Obvious abdominal tuck (waist)  
- Little abdominal fat |
| **Overweight** | - Ribcage, spine not easily palpable  
- Abdominal tuck (waist) absent  
- Obvious abdominal distension |
| **Obese** | - Massive thoracic, spinal and abdominal fat deposits  
- Massive abdominal distension |
The dogs presenting an average index corresponding to an optimal weight have a fat mass of around 13%. When a 5-grade body index is used, every half-grade in the index represents a 10%-increase in fat mass. As a consequence, a dog presenting a body index of 5, which corresponds to the qualification ‘morbid obesity,’ has a fatty mass of over 40%.

The advantage of these index systems is that they can be easily applied by the clinician and that they do not apply exclusively to the diagnosis of obesity but also to its active prevention. It is easy to weigh the animal during a routine consultation and find the value in the index. ✨

**Table 2. Body condition scoring in dogs**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Emaciated</strong></td>
<td>• Ribcage, spine, shoulder blades and pelvis easily visible (short hair) • Obvious loss of muscle mass • No palpable fat on rib cage</td>
</tr>
<tr>
<td><strong>Thin</strong></td>
<td>• Ribcage, spine, shoulder blades and pelvis visible • Obvious abdominal tuck (waist) • No palpable fat on rib cage</td>
</tr>
<tr>
<td><strong>Ideal</strong></td>
<td>• Ribcage, spine, shoulder blades and pelvis not visible but easily palpable • Obvious abdominal tuck (waist) • Thin layer of fat tissue palpable on rib cage</td>
</tr>
<tr>
<td><strong>Overweight</strong></td>
<td>• Ribcage, spine, shoulder blades and hipbones palpable with difficulty • Abdominal tuck (waist) absent • Fat deposit obvious on spine and base of tail</td>
</tr>
<tr>
<td><strong>Obese</strong></td>
<td>• Massive fat deposits on thorax, spine and base of tail • Obvious abdominal distension</td>
</tr>
</tbody>
</table>

**FURTHER READING**

