ADVANCE VETERINARY DIETS

Research reports

A RESEARCH UPDATE FOR THE VETERINARIAN FROM AFFINITY PETCARE

OBESITY AND OVERWEIGHT IN CATS

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Obesity is one of the most common nutritional diseases in cats. The latest studies have shown that the incidence of obesity or excess body weight (BW) in cats ranges from 27% to 55% *(Scarlett et al., 1994; Courcier et al., 2010; APOP Survey, 2011; Vandendriessche et al., 2017; Öhlund et al., 2018).* (Graphs 1 and 2)

Graph 1. Prevalence of feline obesity in different countries (adapted from *Scarlett et al., 1994*; *Lund et al., 2005*; *Courcier et al., 2010*; *APOP Survey, 2011*; *Vandendriessche et al., 2017*; *Öhlund et al., 2018*).

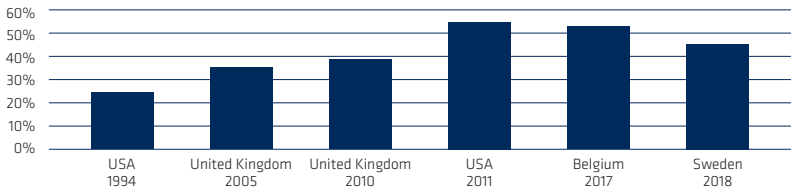
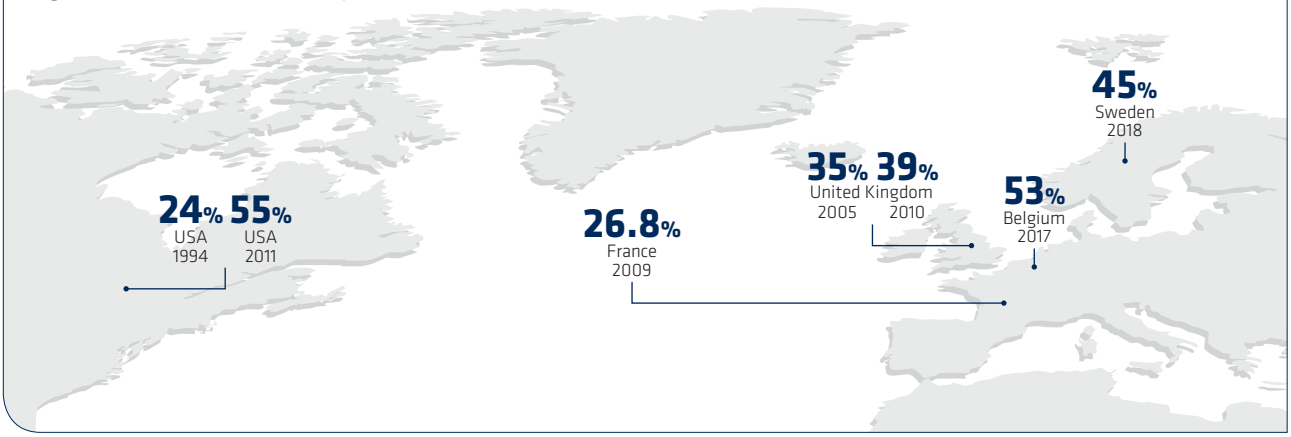


Figure 1. Prevalence of feline obesity in different countries.



1. INTRODUCTION

Animals that weigh 10% in excess of their optimal body mass are considered overweight, while obesity is defined as an excess of over 20%. So, if a cat with an optimal body weight of 4 kg gains 400 g, it is considered to have reached the limit for being overweight. This definition, however, requires information about the cat's ideal weight, which is not always available.

Therefore, the easiest way to assess a cat's degree of obesity or thinness in the clinic is to evaluate its body condition (BC) (Table 1). To this end, a 5-point scale is probably the most representative and practical for use in routine examinations. If necessary, half points can be added to expand the scale.

Body fat percentages reported in various studies for healthy and thin cats range from 13% to 20%, so the optimal mass in cats is open to some degree of interpretation.

On a 5-point scale, an increase of one unit in body condition corresponds to an increase of approximately 10% in body fat and 20–30% in body weight *(Laffamme, 1997)*.

Table 1. Body condition classification for cats (adapted from *Laflamme et al., 1997*).

VERY THIN

Ribs: very evident in short-haired cats; no palpable fat
Vertebral processes: easily palpable in the lumbar region
Pelvis/abdomen: easily palpable pelvic bones
Abdominal tuck: very prominent

THIN

Ribs: easily palpable with minimal fat covering
Vertebral processes: easily visible lumbar vertebrae
Pelvis/abdomen: obvious waist; very little abdominal fat
Abdominal tuck: clearly visible

IDEAL

Ribs: palpable, slight fat covering
Vertebral processes: barely visible
Pelvis/abdomen: discernible waist; minimal abdominal fat
Abdominal tuck: visible

OVERWEIGHT

Ribs: hard to palpate with moderate fat covering
Vertebral processes: hard to palpate under fat covering
Pelvis/abdomen: waist barely visible; rounding of abdomen; moderate abdominal pad
Abdominal tuck: not visible

OBESE

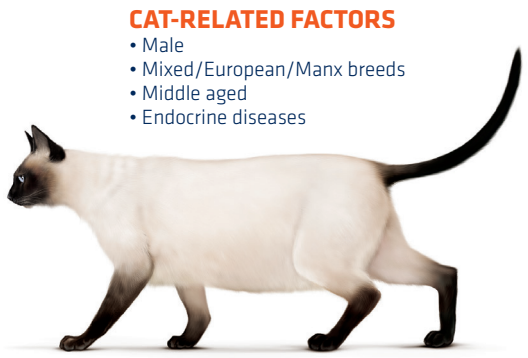
Ribs: not palpable under a thick layer of fat
Vertebral processes: not palpable and completely covered in fat
Pelvis/abdomen: distended abdomen and no waist; extensive abdominal fat deposits
Abdominal tuck: no tuck and a flabby abdomen with accumulated fat

2. RISK FACTORS FOR OBESITY

Figure 2 shows the main risk factors for developing obesity or excess weight in cats.

A cat with an optimal body condition (3 on the scale of 5) has about 22 ± 2% body fat

Figure 2. Risk factors for developing obesity (adapted from *Lund et al., 2005; Colliard et al., 2008; Russel et al., 2002; Scarlett and Donaghue, 1996*).



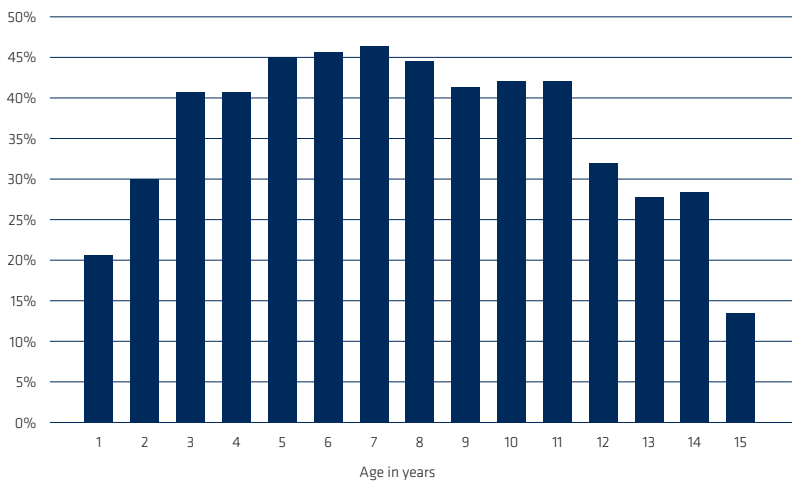
Age is one of the most significant risk factors (Graph 2). Cats start gaining weight at very early ages *(Lund et al., 2005; Scarlett et al., 1994)*. By the age of just 1 year, obesity or excess body weight is already a cause for concern in over 20% of cats.

Body weight reaches a maximum at around 6–8 years of age, at which age 45% of cats are overweight or obese *(Lund et al., 2005)*. By contrast, the risk of obesity apparently declines from the age of 11 onward, probably due to a lower life expectancy for obese cats and greater incidence of diseases with a negative effect on body condition *(Teng et al., 2017)*.

Castrated and male cats also present a higher risk for obesity. The risk of castrated cats being obese or overweight is about three times higher than in entire cats. Male cats are also more prone to obesity. Almost half (41%) of castrated male cats have excess weight *(Lund et al., 2005)*.

Prevention programmes should be initiated early on in the cat's life and which is also when veterinary surgeons should give advice on how to prevent weight gain immediately after castration

Graph 2. Prevalence of obesity and overweight by age in adult cats (adapted from *Lund et al., 2005*).



3. FELINE OBESITY AS A DISEASE

Overweight or obesity in cats does not just correspond to an increase in body weight; in fact it should be considered a disease with multiple consequences for each patient's health and well-being *(Sandøe et al., 2014)*.

Table 2 shows the main diseases affecting obese and overweight cats. In addition, although it has not been proven specifically in cats, obesity is considered to complicate or be associated with heart problems, heat and exercise intolerance, dyspnoea, hypertension and increased risk of complications during anaesthesia and when giving birth. Obesity also complicates the diagnosis and treatment of other illnesses: it is hard to palpate organs, X-rays produce low-quality images because they are partially absorbed by fat, catheters are harder to place and so on.

> Epidemiological studies have shown that obese cats are 2.7 times more likely to die in middle age (8–12 years) than cats with an optimal body condition *(Scarlett and Donoghue, 1996)*

A cat's quality of life and longevity may be adversely affected as a result of being obese *(German et al., 2006; Sallander et al., 2012)*.

3.1 Metabolic syndrome

In human medicine, metabolic syndrome is defined as a group of conditions including abdominal obesity associated with insulin resistance, glucose intolerance, dyslipidaemia, pro-inflammatory state, high blood pressure and/or thrombosis.

Table 2. Relative risk (odds ratio) of certain diseases in overweight or obese cats compared to thin cats (adapted from *Donoghue, 1998; Lund et al., 2005*).

DISEASE	WITH OVERWEIGHT	WITH OBESITY	SOURCE
Lameness	2.9	4.9	*Scarlett and Donoghue, 1998*
Diabetes mellitus		2.2–3.9	*Scarlett and Donoghue, 1998; Lund et al., 2005*
Skin problems		1.5–2.3	*Scarlett and Donoghue, 1998; Lund et al., 2005*
Oral diseases	1.8	1.4	*Lund et al., 2005*
Urinary diseases	1.6	Increased	*Lund et al., 2005*
Neoplasms		2.0	*Lund et al., 2005*
Gastrointestinal diseases		Increased	*Lund et al., 2005*
Hepatic lipidosis		Increased	*Lund et al., 2005*

Graph 3. Plasma concentration of acute-phase proteins (haptoglobin, α1-acid glycoprotein) in thin and overweight cats (adapted from *Jeusette et al., 2009*).

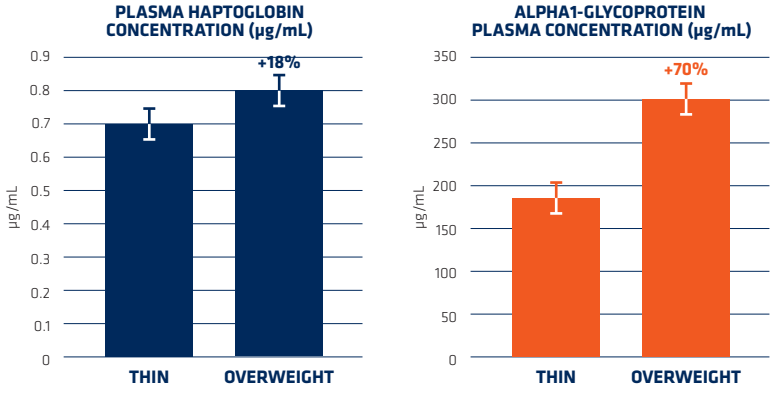
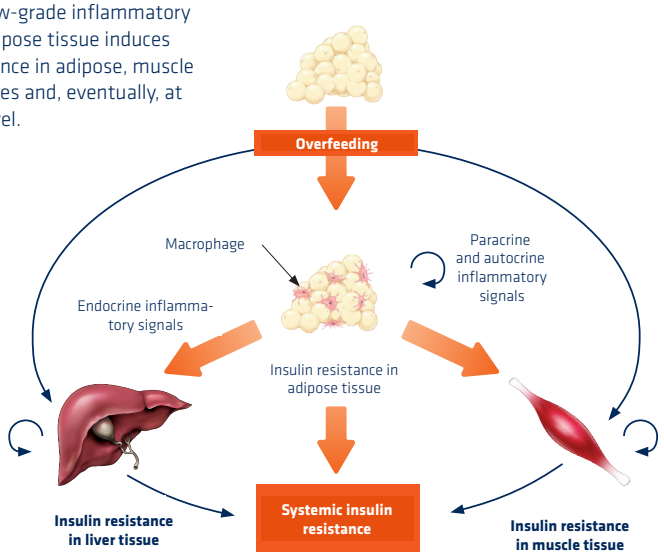
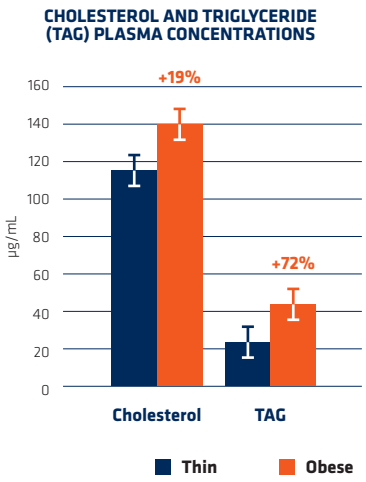


Figure 3. A low-grade inflammatory reaction in adipose tissue induces insulin resistance in adipose, muscle and liver tissues and, eventually, at a systemic level.

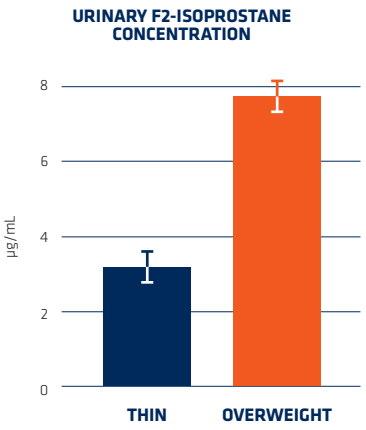


Various scientific studies have shown that obesity and weight gain in cats are also associated with increased expression of inflammatory cytokines (TNF-α, IL-6) and reduced expression of anti-inflammatory adiponectin in adipose tissue *(Hoenig et al., 2006; Belsito et al., 2009)*. Overweight cats also have a higher plasma concentration of acute-phase proteins (α1-acid glycoprotein and haptoglobin) than thin cats (Graph 3) *(Jeusette et al., 2009)*. This inflammatory state may explain the reduction in insulin sensitivity observed in castrated and obese male cats (Figure 3). Indeed, every kilo gained by a cat corresponds to a 30% reduction in insulin sensitivity *(Hoenig et al., 2006)*. This decrease is associated with an increase in blood cholesterol and triglyceride levels (also called hyperlipidaemia) (Graph 4). Obese cats also develop abnormal lipoprotein levels (dyslipidaemia) similar to those observed in humans: increased VLDL and LDL concentrations plus a lower HDL concentration *(Hoenig et al., 2003; Jordan et al., 2008)*.

Graph 4. Cholesterol and triglycerides (TAG) plasma concentrations in thin and obese insulin-resistant cats (adapted from *Hoenig et al., 2003*).



Graph 5. Oxidative stress (indicated by urinary F2-isoprostane concentration) in thin and overweight cats (adapted from *Jeusette et al. 2009*).



3.2 Oxidative stress

In humans, obesity is associated with oxidative stress, which, in turn, is associated with hyperglycaemia, hyperleptinaemia, inadequate antioxidant defences, increased free radicals and chronic inflammatory processes *(Vincent and Taylor, 2006)*.

Affinity Petcare studies have shown that overweight cats present higher levels of oxidative stress, based on an increase in urinary F2-isoprostane, a marker of lipid peroxidation *in vivo*. This indicates there is a relationship between obesity and an increase in pro-oxidant load or increased cellular susceptibility to oxidation (Graph 5) *(Jeusette et al., 2009)*. It remains to be seen whether the change in oxidative state is a predisposing factor for the diseases frequently observed in obese cats (e.g., hepatic lipidosis, hyperlipidaemia, diabetes mellitus, lameness, kidney or urinary tract diseases). It has been shown that cats with diabetes mellitus and kidney failure suffer from oxidative stress *(Falkowski, 2008; Yu and Pateau-Robinson, 2006)*.

3.3 Intestinal microbiota

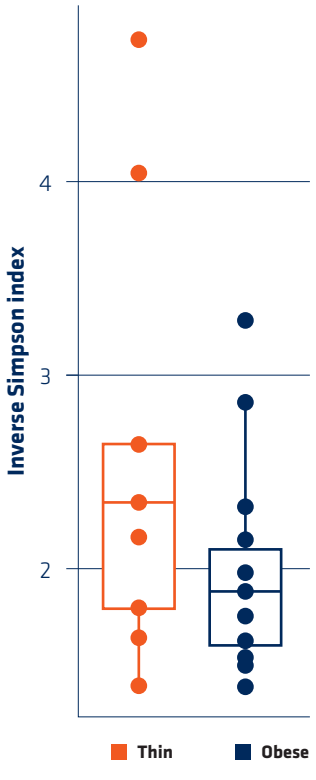
The group of microorganisms found living in the intestine comprise the intestinal microbiota. The latest technological advances in high-throughput DNA sequencing have highlighted the role of these microorganisms in determining their host's immunity and metabolism. Accordingly, studies in mice have shown that transplanting microbiota from obese to thin animals induced the recipients to accumulate fat and, in the long term, assume the donors' obese phenotype *(Turnbaugh et al., 2009)*.

In fact, it has been reported that the microbiota in obese animals is significantly different from that of thin animals.

Obesity has been associated with a change in intestinal bacterial populations to a less diverse microbiota containing a greater proportion of genera with a high capacity for extracting energy from complex carbohydrates *(Tehrani et al., 2012)*.

This change in bacterial composition or its function is apparently related to weight gain and adiposity through

Graph 6. Diversity of microbiota in thin and overweight animals (adapted from *Jeusette et al., 2018*).



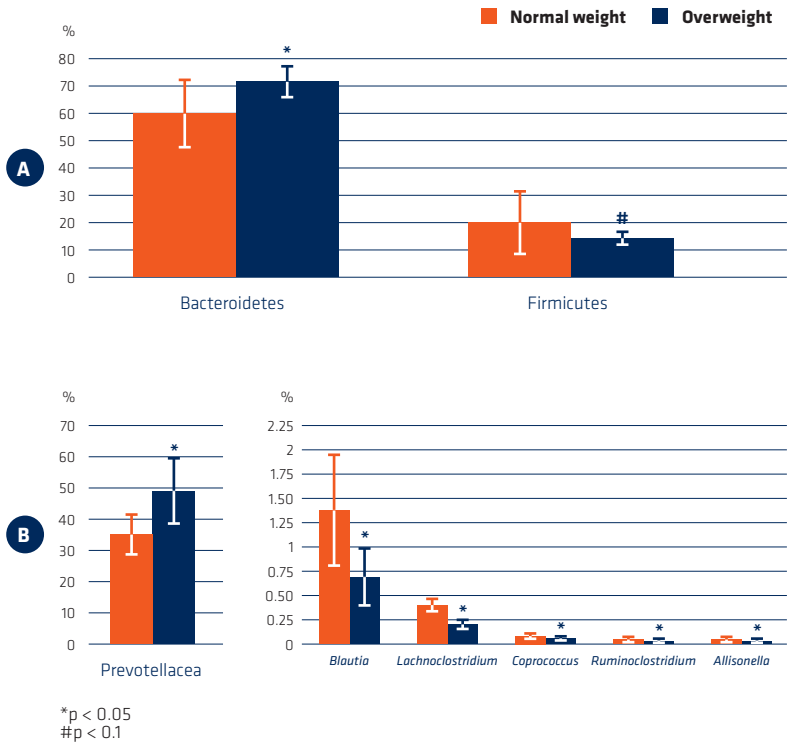
a series of mechanisms including inflammation, increased energy obtained from the diet and a change in the host's satiation hormones *(Flint, 2011)*.

Recent research by Affinity Petcare indicates that overweight or obese cats, as observed in other species, have less microbial diversity (Graph 6) as well as a different composition of certain genera of gut microbiota that play a key role in extracting energy from the diet. In particular, obese cats have a greater abundance of the phylum Bacteroidetes, mainly due to an increase in the family Prevotellaceae, whose function is to produce the hydrogen used to extract more energy from the diet (Graph 7a).

Additionally, obese animals have less abundance of certain genera belonging to the Firmicutes phylum: *Blautia, Lachnoclostridium, Coprococcus 1, Ruminoclostridium 5, Allisonella*, some of which are associated with a healthy microbiota (compared to cases of acute diarrhoea) *(Jeusette et al., 2018)* (Graph 7b).

On the other hand, it has been shown that the rate of weight loss in dogs may be related to the composition of the intestinal microbiota and its production of metabolites *(Kieler et al., 2017)*, so it is reasonable to assume that something similar may happen in cats.

Graph 7. Differences in bacterial composition between thin and overweight cats.
A: at bacterial phylum level.
B: at bacterial genera level.
(adapted from *Jeusette et al., 2018*).



*p < 0.05
#p < 0.1

4. TREATING OBESITY IN CATS

4.1 Owner education and lifestyle changes

It is important to spend time explaining the following points to owners of obese cats:

- How to recognise when a cat is overweight or obese.
- The consequences of obesity on the cat's health and well-being.
- Their cat's daily energy needs and current energy consumption.
- The importance of adhering strictly to the dietary plan and avoiding any supplementary food.
- Means of interacting with the pet other than feeding (nonfood rewards, toys, etc.).
- The importance of lifestyle changes: recreational activities, promoting movement to obtain food, enriching the environment to encourage exploration, avoiding potentially stressful situations, and so on.
- It is also important to:
  - Set the owner targets (ideal weight, rate of weight loss, dates to achieve an ideal body weight); weight loss is a slow process (a 5 kg cat is expected to lose 50 g/week) carried out over very long periods (it will take almost 5 months to lose 1 kg).
  - Explain to the owner that the cat's energy intake will have to be adapted over time to maintain the same rate of weight loss.
  - Inform the owner of possible behavioural changes the cat may present due to a reduced energy intake (begging for or stealing food, amongst others) and how to combat (ignoring begging behaviour, etc.) and change the unwanted behaviour.

4.2 Medical examination before weight loss

Before starting a weight loss programme, a complete physical examination is necessary to rule out any diseases that could complicate treatment, for example, kidney failure, lower urinary tract disease, liver disease, diabetes mellitus, endocrinopathies, and so on.

A complete anamnesis can help uncover any predisposing factors for obesity and provide the current energy consumption.

4.3 Effect of diet: key nutrients

The cornerstone of all weight loss programmes is to achieve a negative energy balance. This means that energy expenditure must be increased (through exercise) and energy intake reduced. One way of restricting the energy intake is to reduce the amount of food, but this would expose the cat to nutritional deficiencies and hunger. Therefore, it is evident that the diet's composition should be changed. The composition can also change a food's thermic effect and therefore increase energy expenditure.

4.3.1 Restrict energy intake

Diets with a reduced energy content are recommended. The goal is to induce a weekly weight loss of between 0.5% and 2% of the subject's initial weight. It is important to avoid overly rapid weight loss (more than 2%/week) to minimise the risk of losing muscle mass and the onset of feline hepatic lipidosis.

Weight loss is usually quicker during the first few months, after which it becomes more gradual. The initial energy intake should therefore be reduced over time to maintain a reasonable rate of weight loss. The ideal method is to start by giving the animal 80% of its current energy intake. A cat's current intake, however, is often unknown because it is being fed *ad libitum*. In such cases, a starting point is to offer 100 kcal/kg BW (approximately 75% of NRC requirements for overweight cats) and adapt the energy intake over time to maintain optimal weight loss.

The transition should be gradual to reduce any stress due to the change in diet. A simple way of doing this is by placing the new food in the usual food bowl and the old or regular diet in a new bowl (similar to the other one). If the cat does not eat the new food within an hour, remove it before the next meal. Repeat the same process at subsequent meals until the cat becomes familiar with the new diet (1–2 days). Finally, start replacing the regular food with the new one in increasing amounts until the cat is eating only the diet food (https://indoorpet.osu.edu).

After 2 weeks, cats should be re-examined and weight loss evaluated: if the dietary regimen has failed (despite the owner following the plan correctly) energy intake must be further reduced (to 70%, 65% or 60% of NRC requirements) and the case studied in greater detail to ensure that the diet is being followed correctly, to establish the cat's energy needs or to exclude endocrine disorders. If the patient loses weight too quickly, the amount of food should be increased in increments of 5–10%. Throughout the weight loss programme, cats should undergo monthly check-ups to confirm they are losing weight at a healthy rate.

Clinical studies generally show an average weekly weight loss rate of 0.5% or 0.8% *(German et al., 2008; Bissot et al., 2009)*.

4.3.2 Reduced fat and functional fats

The most effective way of reducing the energy density of a diet is to reduce the fat content, which means the cat can be given relatively more food (based on weight) and in turn achieve satiety more easily.

For some time, it was thought that carbohydrate-rich diets had a negative effect on the glucose and insulin response in cats. Recent research in cats has shown that high-fat diets result in increased body weights and higher blood insulin levels *(Backus et al., 2007)* and reduced glucose tolerance *(Thiess et al., 2004)* compared to high-carbohydrate diets.

However, a minimum of fat is necessary to meet requirements for fat-soluble vitamins and essential fatty acids. The type of fat is very important. It is essential to provide a source of (omega-6 and omega-3) essential fatty acids through a blend of vegetable, animal and fish oils.

Omega-3 long-chain polyunsaturated fatty acids (LCPUFAs) have anti-inflammatory properties and bring other health benefits (reduction of blood lipids, cardiovascular effects, improved lameness, improved insulin sensitivity, may help prevent hepatic lipidosis) *(Szabo et al., 2003; Ibrahim et al., 2003)*. Furthermore, it has recently been discovered in mice that a diet with fish oil (source of LCPUFAs) prompts a change in gut microbiota that confers the host with resistance to obesity *(Caesar et al., 2015)* (Figure 4).

Olive oil is the main source of monounsaturated fatty acids (MUFAs) and a key component of the Mediterranean diet. In human medicine, the most well-documented effects of olive oil consumption relate to improved insulin sensitivity and a reduced risk of cardiovascular disease. It has also been shown that replacing saturated fats with MUFAs in humans can induce a small but significant loss of body weight and fat tissue without a significant change in total energy or fat intake. Postprandial fat oxidation is higher after a meal with a high MUFA content than after a meal with lots of saturated fat.

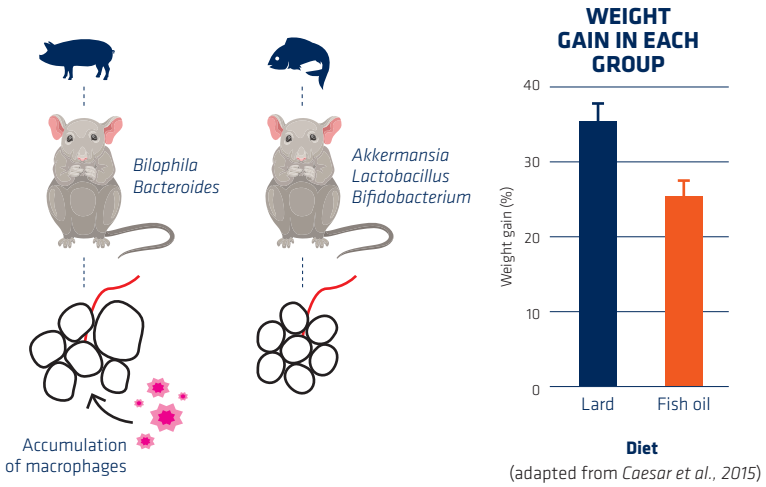
A recent Affinity Petcare study of overweight cats has shown that replacing some saturated fats with olive oil decreases oxidative stress (urinary F2-isoprostane concentrations) (Graph 8) and triglycerides in blood.

But fat also indirectly modifies intestinal microbiota through its impact on bile acid secretion and its antimicrobial activity. Accordingly, studies by Affinity Petcare have shown that a high-fat diet for dogs triggers greater bile acid production, which can have a negative impact on the intestinal microbiota (*Schauf et al., 2018*).

4.3.3 Fibre: satiety and healthy microbiota

Another way of introducing energy dilution is to increase dietary fibre. Fibre can also be used to increase the feeling of fullness. Thanks to their unique physical properties, some types of fibre are especially effective in terms of satiety (Affinity, data on file).

Figure 4. Mice colonised with intestinal microbiota from donor mice were fed a diet based on lard or fish oil for 3 and 11 weeks, respectively.



(adapted from *Caesar et al., 2015*)

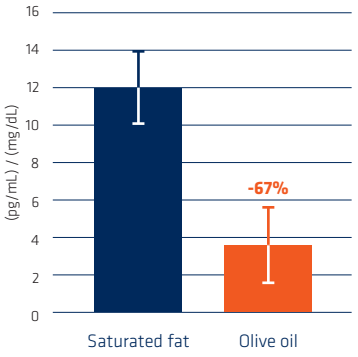
What is more, even some fibres that are indigestible for cats are still used by bacteria in the large intestine and thus act as a nutrient for the microbiota. As such, a high-fibre, low-energy diet can stimulate greater microbial diversity that is ultimately associated with better metabolic health *(Le Chatellier et al., 2013)*.

4.3.4 High-protein, low-starch diet

Once the fat and fibre content has been established, increasing dietary protein at the expense of starch has numerous advantages for obese cats:

- Improves body composition: enhances fat loss and maintains muscle mass more effectively in obese cats following a weight loss protocol *(Laflamme and Hannah, 2005; Hoenig et al., 2007; Vasconcellos et al., 2009)*. Maintaining muscle mass is very important for long-term weight management, as energy expenditure largely depends on muscle mass. A significant loss of muscle mass results in a lower energy requirement, promoting metabolic resistance to weight loss and potential weight regain.
- Permits a higher energy consumption (+10%) for the same weight loss *(Vasconcellos et al., 2009)*.
- Improves insulin sensitivity in obese cats *(Hoenig et al., 2007)*.

Graph 8. Oxidative stress (indicated by urinary F2-isoprostane) after 5 months of diet with saturated fat or olive oil (adapted from *Jeusette et al.*, 2010)



4.3.5 Anti-oxidant and anti-inflammatory compounds: Citrus flavanones

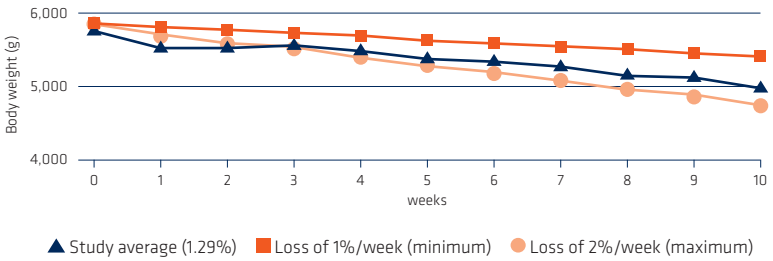
As noted above, the pathophysiology of feline obesity includes inflammatory and oxidative mechanisms. The citrus flavanones hesperidin and naringin (a subgroup of flavonoids) are reported to have antioxidant, lipid-lowering, glucose-lowering and anti-inflammatory activity, which is particularly relevant in obese cats (see below).

4.4 Effect of diet: specific diet

4.4.1 Weight-loss diet

A modified diet (with energy restriction, high protein, low fat and a correct balance of fibres and nutrients) facilitates the loss of fat, while maintaining muscle mass and avoiding vitamin or mineral deficiencies and the feeling of hunger. Trials with the Weight Balance diet in obese cats, where energy was restricted to 71% of requirements, showed an average weight loss of 1.25%/week, as had been planned (Graph 9).

Graph 9. Average weight loss of six cats following the Weight Balance weight-loss diet. Restriction to 71% of requirements.



4.4.2 Microbiota reinforcement

A low-fat diet with the right blend of fibres and an optimal combination of nutrients and ingredients to reinforce the intestinal microbiota, such as Advance Weight Balance:

- Increases microbiota diversity (Graph 10)
- Redresses some of the changes in the microbiota induced by obesity or overweight (Graph 11)

4.4.3 Metabolic reinforcement

Both *Jeusette et al. (2010)* and *Leray et al. (2011)* have shown that supplementing the diet of overweight or obese cats with citrus flavanones (Graph 12):

- significantly reduces oxidative stress (urinary F2-isoprostane);
- significantly reduces blood markers of inflammation (haptoglobin, α1-acid glycoprotein);
- significantly reduces blood lipids (cholesterol and triglycerides).

4.4.4 Reinforcement against diabetes

As *Hoenig et al. (2006)* have shown, weight loss normalises insulin sensitivity in obese cats.

Affinity Petcare has reported significant improvements in glucose metabolism markers (18%, 40% and 21% reductions in fructosamine, basal insulin and amylase, respectively) after just 3 weeks of treatment with the Weight Balance diet.

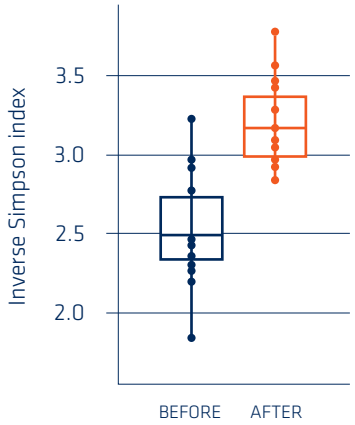
4.4.5 Reinforcement for the liver

Cats, for unknown reasons, have a great tendency to accumulate triglycerides in the hepatocytes. This accumulation probably occurs when there is an increase in TAG synthesis, when fatty acids cannot be oxidised in the mitochondria, or when TAG cannot be exported from the liver as very low-density lipoproteins (VLDL).

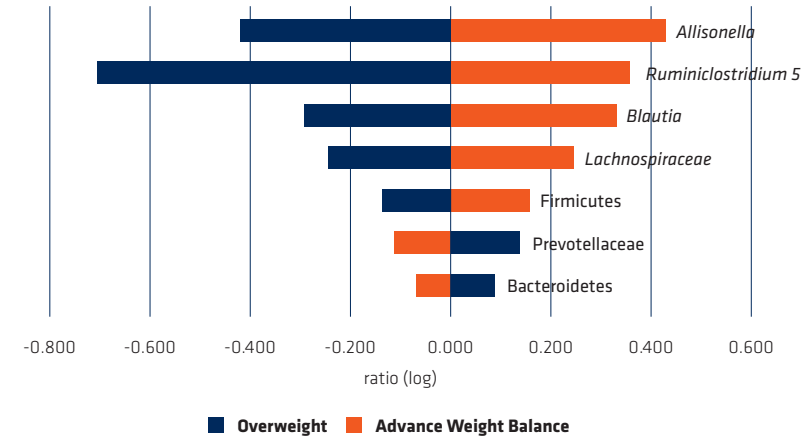
Obese cats are probably predisposed to hepatic lipidosis during periods of reduced consumption due to:

- The amount of free fatty acids that can be rapidly released from peripheral fat deposits.
- A degree of pre-existing insulin resistance associated with the obese state.

Graph 10. Increased microbiota diversity in cats after receiving Advance Weight Balance (internal data).



Graph 11. Effects of the Weight Balance diet on bacterial composition and rectification of changes caused by being overweight or obese.



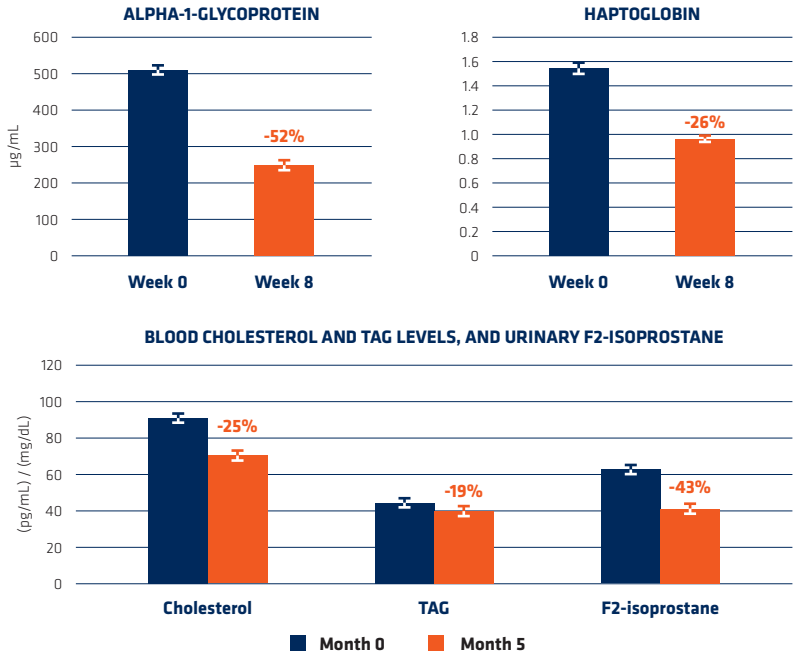
• The underlying level of hepatic lipids is higher in obese cats.

L-carnitine can help improve fatty acid oxidation in the mitochondria and the use of glucose during weight loss *(Ibrahim et al., 2003)*. When there is a lack of carnitine, TAG accumulates in the tissue.

Citrus flavanones may also help limit lipid accumulation in the liver *(Chiba et al., 2003)*.

LCPUFAs levels drop significantly in cats with hepatic lipidosis. Studies have shown that diets poor in omega-3 LCPUFAs increase the likelihood of cats suffering hepatic lipidosis *(Ibrahim et al., 2000; Szabo et al., 2003)*. Affinity Petcare has demonstrated that a 3-month weight-loss programme with the Weight Balance diet, which achieved a 15% reduction in weight, significantly improved hepatic markers (-26% alkaline phosphatase, -28% haptoglobin, lower levels of transaminases and bile acids).

Graph 12. Effect of citrus flavanone supplementation on plasma concentrations of α1-acid glycoprotein and haptoglobin, urinary isoprostane and blood lipids in obese cats (adapted from *Leray et al., 2011*, in press; *Jeusette et al., 2010*).



4.4.6 Reinforcement for the skin

As already mentioned, feline obesity is generally associated with a poor coat and skin problems. It is therefore essential to provide a higher concentration of essential nutrients to maintain hair and skin condition, while restricting energy and fat intake. Essential amino acids, essential fatty acids, zinc and biotin are particularly important.

4.4.7 Reinforcement of joints and bones

Less mechanical pressure on joints thanks to a lower body weight, omega-3 fatty acids and antioxidants are some of the factors that can regulate the pathophysiological alterations that occur in joint diseases.

4.4.8 Reinforcement of the urinary system

Overweight cats have an increased risk of FLUTD. Optimal urinary pH helps minimise this risk. Water intake must be adequate.

4.4.9 Reinforcement of the digestive system

Obese cats suffer from more digestive disorders. Dietary supplementation with prebiotics helps restore gut flora and intestinal health.

4.5 Exercise

It is hard to increase how much a cat exercises *per se*. However, their natural instincts can be stimulated in order to encourage physical activity:

- Curiosity: enrich the environment to motivate exploration (garden, windows, boxes, climbing elements, tubes, etc.).
- Hunting: simulate hunting with toys (mouse, balls, feathers at the end of a stick, etc.).
- Feeding: persuade the cat to follow its owner in order to obtain food and use food dispenser balls or interactive feeders.

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A CLINICAL REPORT FOR THE VETERINARIAN FROM AFFINITY PETCARE

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