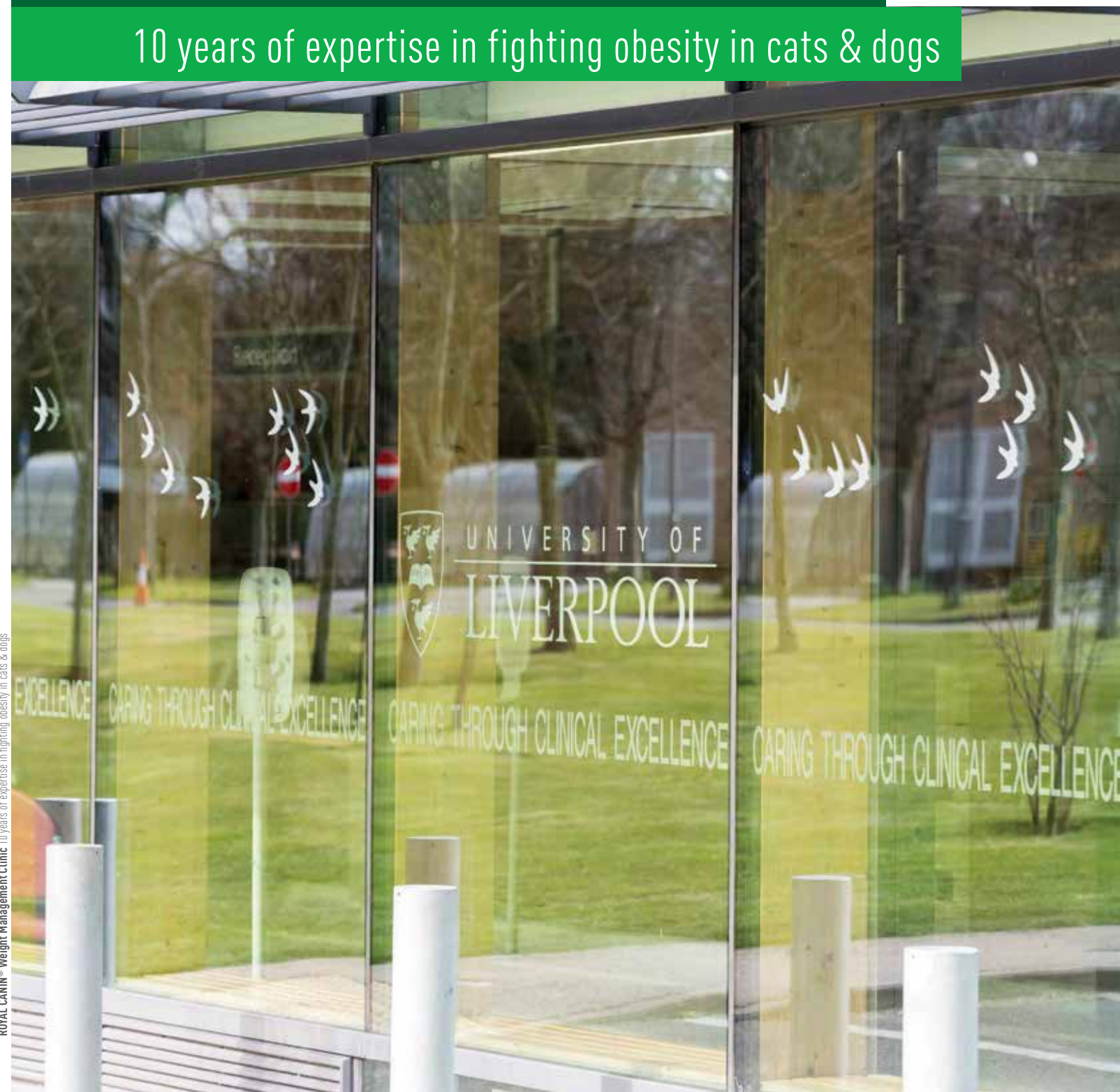


ROYAL CANIN® Weight Management Clinic

10 years of expertise in fighting obesity in cats & dogs



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ROYAL CANIN® Weight Management Clinic 10 years of expertise in fighting obesity in cats & dogs

Practical tools and knowledge sharing

Besides providing a better understanding of obesity, the collaboration between ROYAL CANIN® and the ROYAL CANIN® Weight Management Clinic led to the development of many practical tools to help the vet practitioners (and vet nurses) better manage weight loss in cats and dogs, and to facilitate communication with the pet owner. Feel free to get in touch with your local ROYAL CANIN® contact for more information.



Weight Management Clinic

In partnership with **ROYAL CANIN**

www.pet-slimmers.com

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Index

I. ROYAL CANIN® Weight Management Clinic presentation

1. The concept: a state of the art obesity clinic
2. The staff
3. Interactions with ROYAL CANIN® & WALTHAM Centre for Pet Nutrition teams
4. The typical pathway of an obese patient at the ROYAL CANIN® Weight Management Clinic

II. 10 years of scientific discoveries: new insights into obesity

1. Benefits of weight loss
2. Owner education
3. Adverse health effects of obesity
4. Nutritional strategies for weight management
5. Pathogenesis of obesity-associated diseases
6. Epidemiology & risk factors for obesity
7. Tools for assessing obesity in dogs and cats

III. 10 years of expertise in pet obesity: truth and fallacies

IV. Future research: what will the next 10 years bring?

V. Scientific References: 10 years of research performed at the ROYAL CANIN® Weight Management Clinic

The Authors :



Marie-Anne Hours

DVM

Marie-Anne Hours graduated from the National Veterinary School of Toulouse in 2007. After an internship in equine clinical sciences and 2 years of veterinary practice, she worked as an editor for the veterinary press. She joined ROYAL CANIN®'s R&D, within the Scientific Communications department in 2011, with a special interest on weight management topics and endocrinology.



Hélène Charles

DVM, CES Nutrition


Hélène Charles graduated from the National Veterinary School of Maisons-Alfort in 2003. After 6 years as a vet practitioner, she joined ROYAL CANIN® France as trainer & scientific support for the veterinary channel. In 2014, she joined the Scientific Support team within R&D, with a special interest on weight management and immunology topics.




Key numbers

280 cases followed
in the ROYAL CANIN®
Weight Management clinic

 **1 043 kg**
of fat lost

 **20 %**
bodyweight lost
on average

 **56 859**
total number of days dieting
for ROYAL CANIN® Weight
Management Clinic patients

1 149 days
duration of the longest
weight loss programme

 **92 %**
compliance after 2 months ...

86 % after
3 months

& 73 % after
7 months
for the ROYAL CANIN®
Weight Management programme



I

ROYAL CANIN® Weight Management Clinic

presentation

The concept: a state of the art obesity clinic

In 2005, in collaboration with the WALTHAM Centre for Pet Nutrition, ROYAL CANIN® supported the creation of **a state of the art obesity clinic** based at the University of Liverpool's Small Animal Teaching Hospital. The objective was to be able to follow, in the best scientific setting, weight loss and weight maintenance programmes in real field conditions.

The ROYAL CANIN® Weight Management Clinic was the first of its kind in Europe, and aimed to provide an outstanding service to clients and veterinary surgeons alike. In this **referral clinic**, cases are investigated and treated in the same professional manner as with all the University's referral services. In addition to facilitating the treatment of many overweight cats and dogs, the clinic allows to compile a huge amount of information about obesity in pets.

In the past 10 years, this information has been used not only to demonstrate the efficacy of ROYAL CANIN® weight management diets in real field conditions, but also to develop a better understanding of obesity in pets, and to refine methods of treatment and prevention. ■

Key numbers

105 scientific communications,

51 articles published in peer-reviewed journals and

54 research abstracts

193 continuing education talks given in **51** countries



The staff

Dr Alex German

BVSc (Hons), PhD, CertSAM, DipECVIM-CA, MRCVS



Alex German is a *Reader in Small Animal Medicine*, at the University of Liverpool, and has been practising veterinary medicine for over twenty years. He is both a *European and Royal College of Veterinary Surgeons* recognised specialist in small animal internal medicine.

Ten years ago, he recognised that obesity was the biggest medical problem facing the pets of our time, and since then, has dedicated his career to improving how it is treated. He regularly lectures to veterinary professionals and pet owners across the world, and has published over 100 research articles in his field. ■

Shelley Holden

VN, Cert CAB (BVNA), Cert SAN, MBVNA



Shelley Holden is a veterinary nurse in Obesity and Metabolic Health Science. Shelley qualified as a Veterinary Nurse in 1997. She completed the Advanced Pet Health Counsellor Course in 2003 followed by the BVNA Cert in Companion Animal Behaviour.

After many years of setting up and successful running nursing clinics in general practice, Shelley moved to the University of Liverpool to become the first clinic nurse for the ROYAL CANIN® Weight Management Clinic.

In addition to this role, Shelley has lectured internationally on Obesity and has written several articles on this subject area. In 2009, she

also gained her Certificate in Small Animal Nutrition. In 2014, Shelley joined ROYAL CANIN® UK as a weight management specialist in the Veterinary Marketing and Sales team. ■

Dr Vincent Biourge

DVM, PhD, Dipl. ACVN, Dipl. ECVN



Vincent Biourge graduated from the Faculty of Veterinary Medicine of the University of Liège (Belgium) in 1985. He remained as an assistant in the Department of Nutrition for two years before moving to the Veterinary Hospital at the University of Pennsylvania (Philadel-

phia, USA) and later to the Veterinary Medical Teaching Hospital of the University of California (Davis, USA). In 1993, Dr. Biourge was awarded a PhD in Nutrition from the University of California and he became a Diplomate of the American College of Veterinary Nutrition. In 1994, he joined the Research Centre of ROYAL CANIN® in Aimargues (France) as Head of Scientific Communication and Nu-

tritionist, and managed the nutritional research program of ROYAL CANIN® between 1999 and 2007. In 2008, Vincent became the Research Centre's Health & Nutrition Scientific Director. ■

Interactions with ROYAL CANIN® & WALTHAM Centre for Pet Nutrition teams

1 Clinical research

ROYAL CANIN® Research & Development Centre (Aimargues, France)

2 Fundamental research

WALTHAM Centre for Pet Nutrition (Waltham on the Wolds, UK)

3 The Clinic

The ROYAL CANIN® Weight Management Clinic (Liverpool, UK)

Scientific communications and lectures
General public awareness on pet obesity



The typical pathway of an obese patient at the ROYAL CANIN® Weight Management Clinic

Pre Consult Questionnaire



Sent to the owner before the 1st consultation

- Collection of full information about the patient's lifestyle and dietary history
- 5 different sections:
 - Patient information
 - Family information
 - Feeding & treating
 - Exercise & behaviour
 - Environment

First Consultation



Half day duration

- Full clinical examination
- CBC (complete blood cell) count, serum biochemical analysis, urinalysis.
- Appropriate diagnostic investigations for any associated disorder.
- Assessment of body weight and body composition (DEXA Scan, Body Condition Scoring, Morphometric measurements)
- Determination of target body weight and tailor made weight loss regimen using ROYAL CANIN® Weight Management diets
- Owner counsel for lifestyle modifications (feeding habits, activity, etc.)

Monitoring



Every 7-21 days

- Clinical examination
- Body weight measurements
- Adjustment of dietary plan if necessary (based on the rate of weight loss and information provided by owner or diary records)

End of weight loss



When target bodyweight is reached

- Full clinical examination
- CBC count, serum biochemical analysis, urinalysis
- Assessment of body weight and body composition (DEXA Scan, Body Condition Scoring, Morphometric measurements)
- Determination of daily rations to maintain stable bodyweight : weight check every two weeks with sequential increase of calorie intake until bodyweight is stable

Maintenance after weight loss



Periodic assessment, as required

- Regular weight checks to avoid weight rebound



- Thorough collection of all information of interest to deal with obesity



- DEXA scan, the gold standard method to assess body composition



- Tailor made adjustments of the regimen
- Regular phone calls and counsel



- Determination of maintenance energy allocation



- Long term follow-up

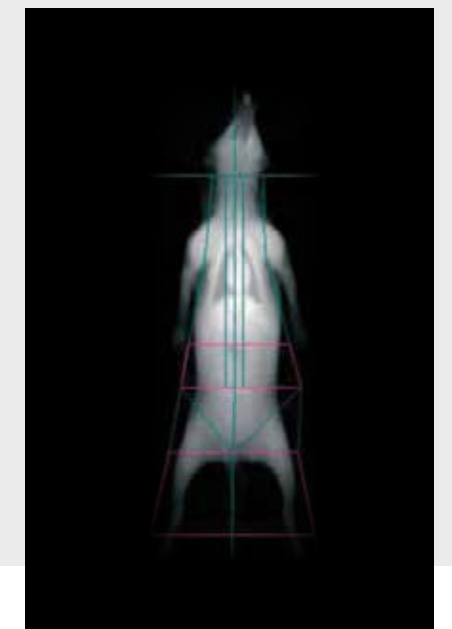


Focus on DEXA SCAN

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 as the reference method to measure both body fat and non-bone lean tissue in various species.

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. 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 is also safe and quick, requiring only 3-4 minutes for a whole body scan in a medium-size dog. This technique has been frequently used as a non-invasive gold standard when validating other methods of composition analysis. ■




Key numbers

Primary care veterinarians only record the overweight status of dogs in **1.4 %** of cases

 **30 %** dogs never weighed

No assessment of Body Condition in **71 %** dogs

 **66 %** owners misperceive their dog's body condition

 **80 %** owners underestimate overweight dog's body condition



Focus on OWNER DIARY

Through the entire weight loss programme supervised by the ROYAL CANIN® Weight Management Clinic, owners are encouraged to fill in a diary that covers the diet ration fed, daily activity, and any additional food that is consumed (either given as treats or stolen).

At each follow-up visit, the information contained in the diary helps to adjust the weight-loss plan as necessary. If progress is good, the diet remains unaltered, and the owner is encouraged to step up activity whenever possible. If the patient has gained weight or

has not lost enough weight, the potential causes are investigated, based upon the information provided by the owner in diary records and discussions during the consultation. ■





II

10 years of scientific discoveries: new insights into obesity

At the ROYAL CANIN® Weight Management Clinic, research focuses on all aspects of obesity, from causes and consequences to the outcome of weight management. Of course, many protocols address the nutritional management of overweight pets or clinical trials of new products, but the objective is also to gain a broader knowledge of the disease. This includes epidemiological data, methods of measuring body composition, pathogenesis and associated diseases, as well as benefits associated with weight loss. Below is a selection of studies performed by the ROYAL CANIN® Weight Management Clinic that have brought a new perspective to the knowledge of pet obesity.

Benefits of weight loss

Quality of life improves after weight loss

This ROYAL CANIN® Weight Management Clinic study, published in 2012, provided the first scientific evidence of the benefits of weight loss on quality of life. This study included 50 obese dogs, of various breeds and genders, referred to the ROYAL CANIN® Weight Management Clinic. A weight management protocol was instigated for each dog, using ROYAL CANIN® Weight Management diets. Owners were asked to complete a standard-

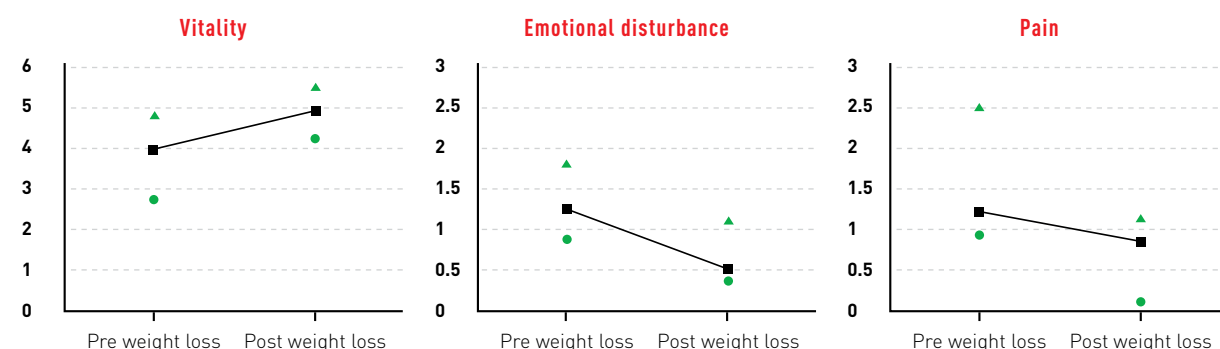
dised questionnaire designed to determine health-related quality of life (HRQOL) prior and after weight loss. Their answers were converted into scores on a scale of 0-6, corresponding to a range of four factors: vitality, emotional disturbance, anxiety and pain. Quality of life improved in the dogs that successfully lost weight. Vitality scores were indeed significantly increased, and pain scores were significantly decreased after weight

loss: the more body fat lost, the greater the improvement in vitality scores.

These results demonstrated that losing weight has a very positive impact on the dog's quality of life. This information can be used to help convince owners of obese dogs of the importance of making their pets lose weight. ■

German AJ, Holden SL, Wiseman-Orr ML, Reid J, Nolan AM, Biourge V, Morris PJ, Scott EM. Quality of life is reduced in obese dogs but improves after successful weight loss. Vet J. 2012 Jun;192(3):428-34.

Effect of weight loss on Health-Related Quality of Life



Owner education

Veterinarians educating their clients and raising awareness about overweight and obesity... still a long way to go!

As in human populations, overweight and obesity are increasingly prevalent in our pet animals. However, even though **veterinarians** are aware of their health consequences, some recent studies have shown that **they may not communicate enough about weight and about the pet's weight status with its owner**. Body weight and body condition assessments are simple to perform and can provide useful information about the pet's health, as well as helping to determine appropriate drug dosage. These tools can also be used to raise owner awareness about obesity.

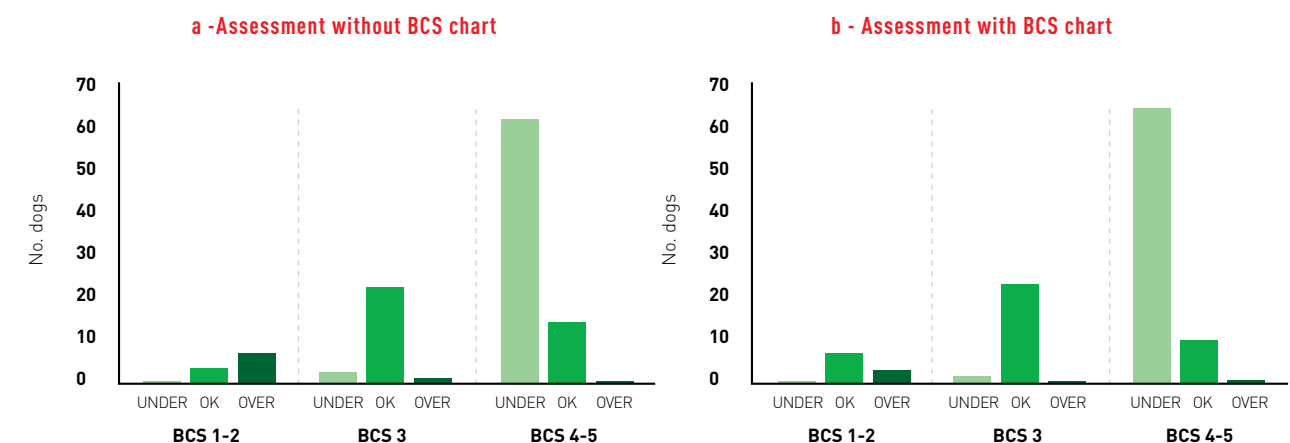
• In one study that reviewed data from approximately **2000 consultations involving 148 dogs**, body weight assessment was made only in 1 out of 4 consults. Further, there was no evidence of any body weight assessments in 30% of the dogs. Body condition was not considered in 71% (1 in 7 consultations) and, even when it was, rarely was a body condition score actually recorded - in fact, only once in the 2000 consultations.

• In another study aiming to determine how often the overweight status of dogs was recorded in first-opinion practice, the results were startling: the **estimated prevalence of overweight and obesity in the UK is > 50%, and the overweight status of dogs was only recorded in 1.4% of the charts** (671 out of 49,488). When looking at what was likely to incite the vet to record the overweight status, not surprisingly, they found a dog was more likely to be recorded as overweight when the consult was for osteoarthritis or lameness, or when the dog was engaged in a practice health scheme (in which discussions about maintaining a healthy weight are expected).

• Lastly, it is important to bear in mind that the owner cannot be relied on to estimate the condition of their pet reliably, even with tools such as Body Condition Score charts. A recent study showed that **owners tend to "normalise" their dog's body condition, more remarkably so when the dog is overweight or obese** (81-85% underestimation, with or without the BCS chart). Misperception of body condition was common (66%) without the BCS chart, and persisted when the chart was used, suggesting that owners might be unwilling to admit their dog is overweight and/or had a preconceived idea of their pet's body condition and simply used the BCS chart to confirm their first opinion. ■

German, A.J., Morgan, L.E. (2008) How often do veterinarians assess the bodyweight and body condition of dogs? Veterinary Record 163, 503-505.
Rolph, N.C., Noble, P.J.M., German, A.J. (2014). How often do primary care veterinarians record the overweight status of dogs? Journal of Nutritional Science 3, e58. doi:10.1017/jns.2014.42.
Eastland-Jones, R.C., German, A.J., Holden, S.L., Biourge V, Pickavance, L.C. (2014). Owner misperception of canine body condition persists despite use of a body condition score chart. Journal of Nutritional Science 3, e45. doi:10.1017/jns.2014.25.

Accuracy of owner's estimation of their dog's body condition without (a) or with (b) BCS chart (5 points-scale).



Educating clients and incorporating exercise for weight loss programmes: it works!

Client education

Associations have been demonstrated between weight gain and the number of meals fed daily, feeding of table scraps and treats, the dog being present during preparation of food, and the quality of the brand of dog food fed. Weight management strategies usually require the owner to make fundamental changes in their dog's lifestyle, including controlling feeding practices. A ROYAL CANIN® Weight Management Clinic study recently showed that **when clients were counselled about lifestyle and activity alterations on top of dietary restriction, the type of food** (dry, wet, home-cooked...) and the **feeding and treat-giving practices** (number of meals, method of evaluating amount of food, nature of treats...) **prior to the weight loss program did not have any impact on the outcome or on the rate of weight loss.** Owners were more likely to continue giving purchased snacks than table scraps or other treats, suggesting that vets were more adamant against using the latter and/or the owners were more easily persuaded to stop giving them. ■

Interest of exercise

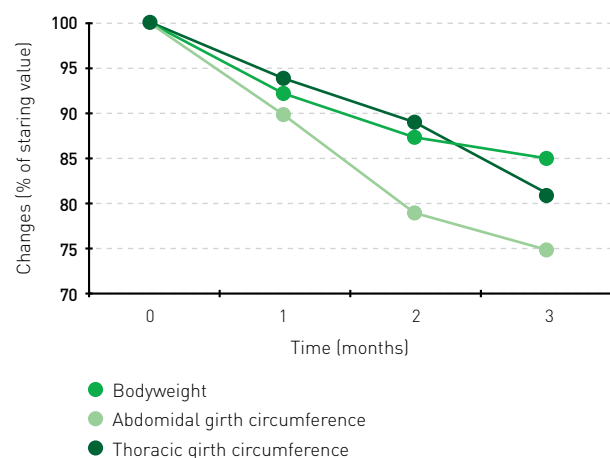
Another study showed that **adding regular exercise sessions** on an underwater treadmill, on top of a daily walk, to a similar weight loss programme (also with weekly educational lectures on pet health for the owners) **could improve both the rate of weight loss and the health of the dogs concerned.** In this study, the mean rate of weight loss for the whole study (3 months) was $1.5 \pm 0.37\%$ per week, whereas in other studies the weight loss rate is often closer to 0.8% per week, and over the course of the study, the mean session speed, session

duration, and distance that the dogs were able to travel per session increased significantly, showing a better physical condition. ■

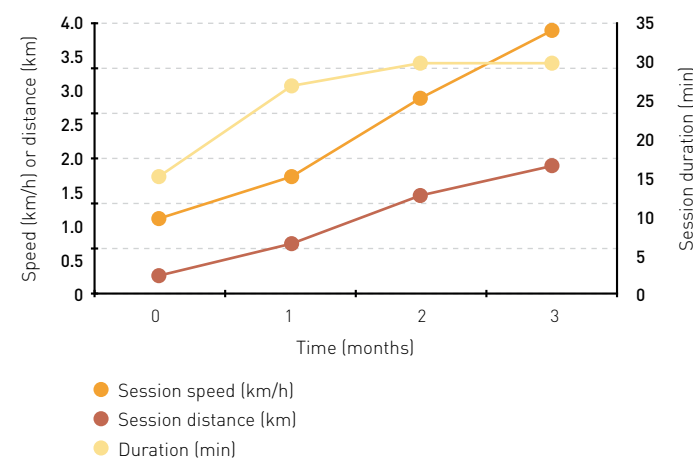
- German, A.J., Holden, S.L., Gernon, L.J., Morris, P.J., Biourge, V. (2011) Do feeding practices of obese dogs, prior to weight loss, affect the success of weight management? *British Journal of Nutrition*, 106, S97-S100.
- Chauvet, A., Laclair, J., Elliott, D.A., German, A.J. (2011) Exercise and Active Client Motivation Improve Rate of Weight Loss in Obese Dogs. *Canadian Veterinary Journal*, 52, 491-496.



Changes in body weight and body measurements over the course of the programme



Speed and distance during treadmill exercise & session duration over the course of the programme



A weight loss regimen is cost neutral for most of owners

A ROYAL CANIN® Weight Management Clinic study compared the average costs of feeding an obese dog before weight loss and during a weight loss programme.

Weight loss in obese dogs generally involves feeding a purpose-formulated diet over a long period of time, but the cost of the food may deter some owners from starting a weight management programme. This study aimed to calculate the cost of feeding an obese dog during weight loss, and to compare this to food costs prior to weight loss. Twenty-two dogs followed at the ROYAL CANIN® Weight Management Clinic, that had successfully reached their target weight and for whom full dietary information was available, were included. The average daily cost of the diet fed before weight loss was calculated, including the main meal and extras (treats, table scraps, etc...) and was compared to the cost of feeding during weight loss. Median daily food cost prior to weight loss was £0.64/day (from £0.26 to £3.31), and was not significantly different from median daily food cost during weight loss (£0.90, from £0.26 to £1.36).

This study demonstrated that, on average, weight management is cost neutral. This information is of great interest to help veterinarians to reassure owners before starting a weight loss programme. ■

German AJ, Luxmore J, Holden SL, Morris PJ, biourge V. feeding obese dogs during weight loss is on average cost neutral. *Journal of Small Animal Practice*, 2015 doi: 10.1111/jsap.12338

Measuring cups: tricky friends!

Even for trained people, with cups marked for the correct amount of food (previously weighed), **measuring out food portions accurately using measuring cups is almost impossible.**

A ROYAL CANIN® Weight Management Clinic study showed up to a 15% variation for repeated measures by the same person, and up to 28% comparing different persons. Further, the amount of kibbles was almost always overestimated, up to 80% more than the expected amount! This inaccuracy (overestimation) was greater for small size portions, typically the amounts that would be fed to cats or small dogs..

Overfeeding on a regular basis can lead to obesity, and for pets on a weight loss programme this inaccuracy can lead to failure...

Another tricky aspect of the measuring cups: the graded scale on the cup can be misleading! In the same study, **4/6 graded scales were inaccurate, with an inaccuracy of up to 40%.**

Weighing is definitely the only reliable solution to measure daily portions. ■

- German, A.J., Holden, S.L., Mason, S.L., Bryner, C., Bouldoires, C., Morris, P.J., Deboise, M., Biourge, V. (2011) Imprecision when using measuring cups to weigh out extruded dry kibbled food. *Journal of Animal Physiology and Animal Nutrition*, 95, 368-373.



Key numbers

Up to **80 %** overdose when using measuring cups

15 % variation for repeated measures by the same person, and up to

28 % comparing different persons.

Weight loss programmes: what outcomes should be expected?

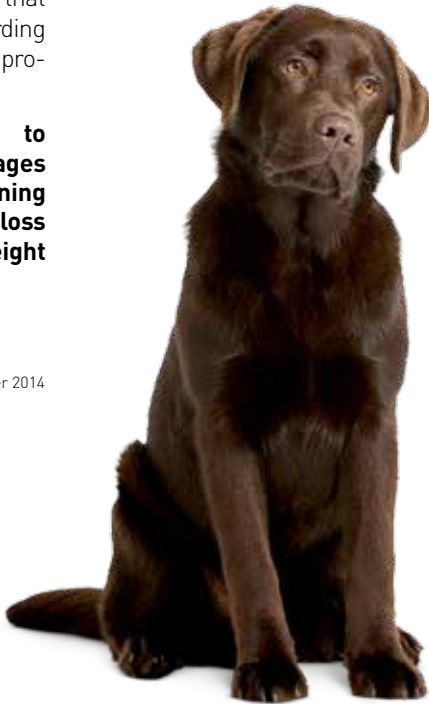
Data were reviewed from 149 obese and overweight dogs enrolled in weight loss programmes, and a number of patterns are evident:

- **The longer the programme, the worse the owners' compliance** (with 3% dropping out at 1 month and 37% at 20 months);
- **As the cumulative percentage of weight loss increases, both the rate of weight loss and energy intake (to maintain weight loss) decreases.**

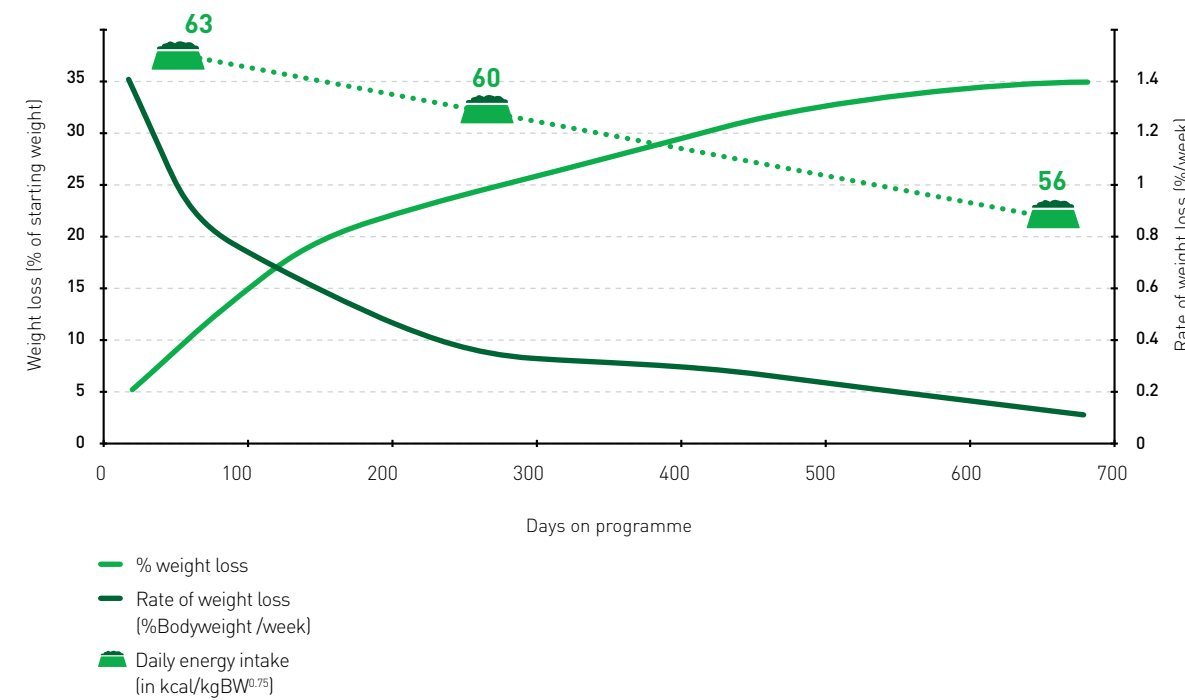
Deagle G., Holden, S.L., Biourge, V., Morris, P.J., German, A.J. (2014), The kinetics of weight loss in obese client-owned dogs European College of Veterinary Internal Medicine Congress; Mainz, Germany. September 2014

Even when we target a weight loss rate of 1 to 2% per week when adjusting the daily rations, the rate that is actually obtained varies according to the stage of the weight loss programme.

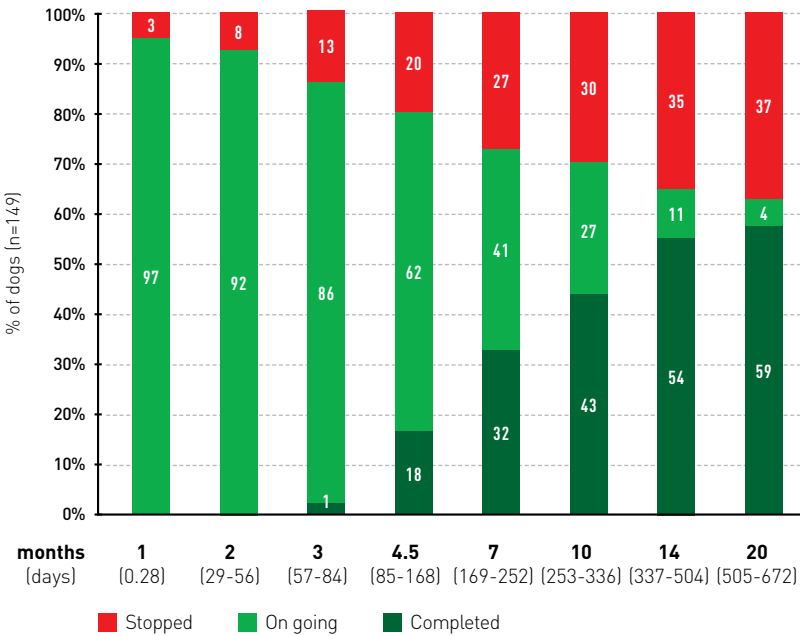
Since it is much easier to lose weight in the early stages than later on, studies examining only the first months of weight loss do not reflect the entire weight management process.



Evolution of weight loss, rate of weight loss and energy intake during weight loss programmes

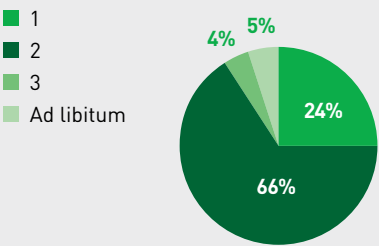


Owner compliance and overall success of weight loss programmes



Key numbers about feeding habits in dogs

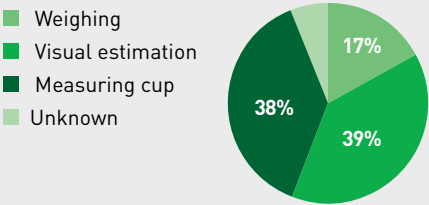
Number of meals



Treats

- 43%** Purchased
- 25%** Table scraps
- 87%** Petfood
- 85%** Human food (cheese, bread, biscuits...)

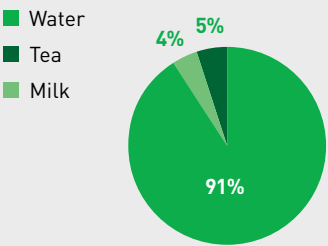
Method to assess food quantities



Type of food

- 76%** Dry food
- 40%** Wet food
- 43%** Mixed-feeding (wet & dry)
- 23%** Home-made diet

Beverage



German, A.J., Holden, S.L., Gernon, L.J., Morris, P.J., Biourge, V. (2011) Do feeding practices of obese dogs, prior to weight loss, affect the success of weight management? *British Journal of Nutrition*, 106, S97-S100.

Adverse health effects of obesity

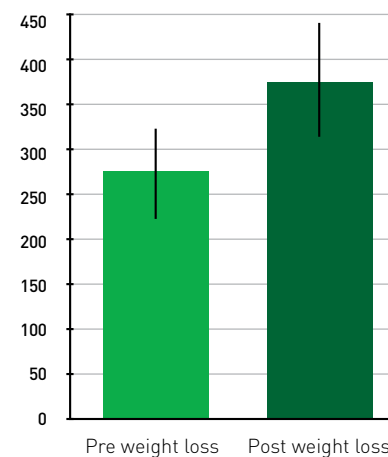
Respiratory consequences of obesity

What is the impact of obesity on respiratory parameters during sedation? A prospective study assessed changes in oxygenation and ventilation as part of normal monitoring of dogs when sedated for their DEXA scan, before and after weight loss. Obesity had a significant effect on oxygenation, but not ventilation, and that oxygen status improved af-

ter weight loss. Among all the factors that might affect oxygenation parameters (age, sex, bodyweight, total and regional body fat mass), the thoracic fat was found to have the greatest impact. ■

Mosing M, German AJ, Holden SL, MacFarlane P, Biourge V, Morris PJ, Iff I. Oxygenation and ventilation characteristics in obese sedated dogs before and after weight loss: a clinical trial. Vet J. 2013 Nov;198(2):367-71.

Oxygenation Ratio ($\text{PaO}_2/\text{FiO}_2$)



PaO_2 = Arterial oxygen partial pressure
 FiO_2 = Inspired oxygen fraction

Do concurrent diseases influence the success of weight management?

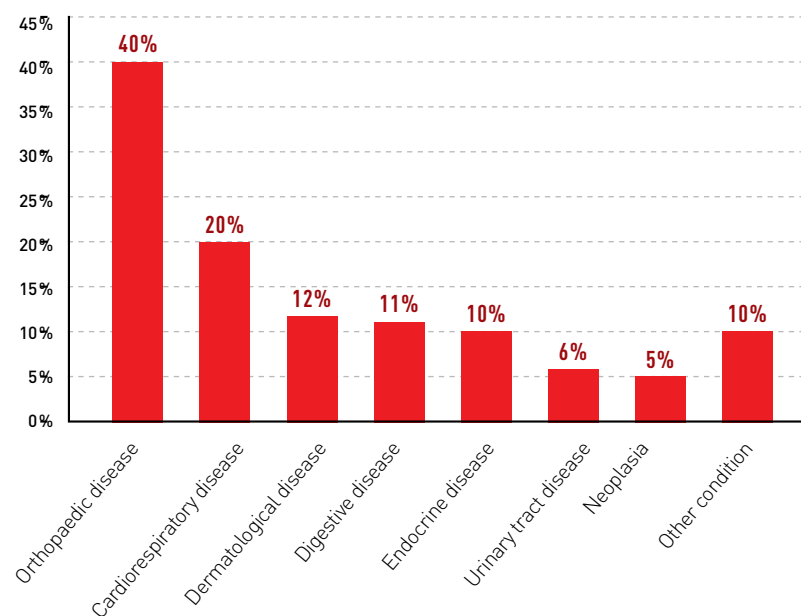
In this study, involving 82 obese dogs that had successfully reached their target bodyweight, outcomes of weight loss were compared in dogs with and without concurrent diseases. Most dogs (84%) had at least one concurrent disease, most frequently orthopaedic disease (40%), but also cardiorespiratory (20%), dermatological (12%), digestive (11%), endocrine (10%) or urinary tract disease (6%). When analysing body composition results, the initial body fat percentage was greater in dogs with either concurrent orthopaedic ($p=0.03$) or dermatological ($p=0.03$) disease, than in dogs without these diseases. Energy intake during weight loss was also negatively associated with the presence of concurrent orthopaedic disease in neutered dogs, requiring greater energy restriction to achieve the same weight loss. The other outcomes of the weight loss programme (rate of weight loss, percentage of weight loss, and lean tissue loss) were not affected by the presence of a concurrent disease.

These results indicate that although concurrent medical diseases are very common in obese pets, affecting more than 80% of the dogs seen at the ROYAL CANIN® Weight Management Clinic, most weight loss outcomes remain the same. However, con-

sidering that dogs with orthopaedic disease require greater energy restriction, their weight loss plan should be tailored accordingly. ■

German, A.J., Andrews, A., Holden, S.L., Morris, P.J., Biourge, V. (2014) Does concurrent disease influence the success of weight management in obese dogs? 57th British Small Animal Veterinary Association Congress, Birmingham, UK; April 2014

Concurrent diseases observed in 82 obese dogs



Key number

About **80 %** of obese patients have concurrent diseases. Nevertheless, these concurrent diseases do not impact the success of the weight loss programme.



Nutritional strategies for weight management

What is the best diet for promoting weight loss in obese cats and dogs?

Weight loss programmes for dogs and cats are not always successful in private practice and a great deal of research has therefore been conducted on nutritional strategies. These aim to meet the nutritional needs of pets whilst at the same time making the pet feel fuller for longer, thus making the owner's task easier and increasing the chances of a positive outcome by improving satiety. This research has highlighted that cats are not dogs and may need food with a different nutritional profile than dogs to achieve the same goal.

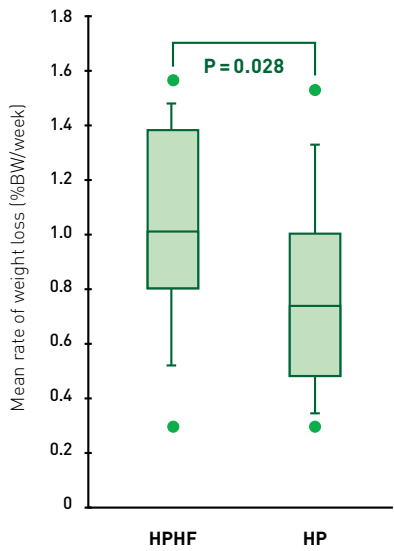
Nutritional strategy for dogs

A first study performed in collaboration with the ROYAL CANIN® Weight Management Clinic, in 2007, showed that when comparing three diets formulated for weight loss and mainly differing in their protein and fibre contents (HPHF vs. HP vs. HF¹), the best satiating effect was obtained with the HPHF food: lower spontaneous intake during the first meal of the day, lower total energy intake during repeated meals at hourly intervals for 3 hours and lower energy intake during two meals (3h interval), even when the first meal was restricted to the amount that would be fed during a weight loss programme.

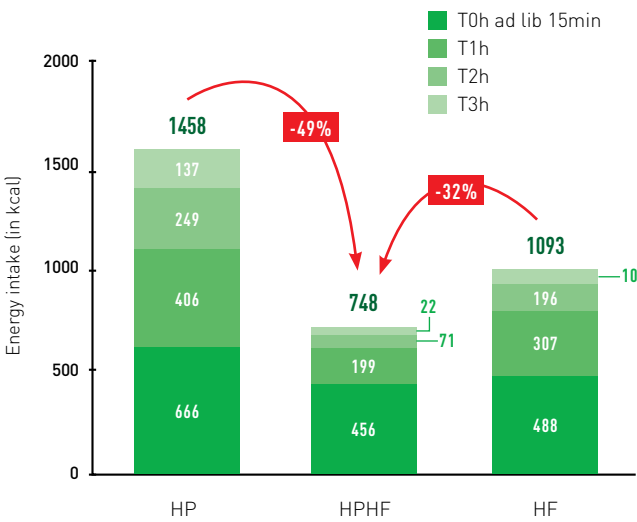
Another later study among obese dogs, owned by clients, showed that in a weight loss programme comparing this HPHF diet to a HP diet, there were no significant differences in weight loss duration or mean energy allocation but that the overall percentage of weight loss, mean rate of weight loss and percentage of fat mass loss were greater with the HPHF diet.

For dogs, a high protein high fibre (HPHF) diet not only improves satiety but also improves weight loss.

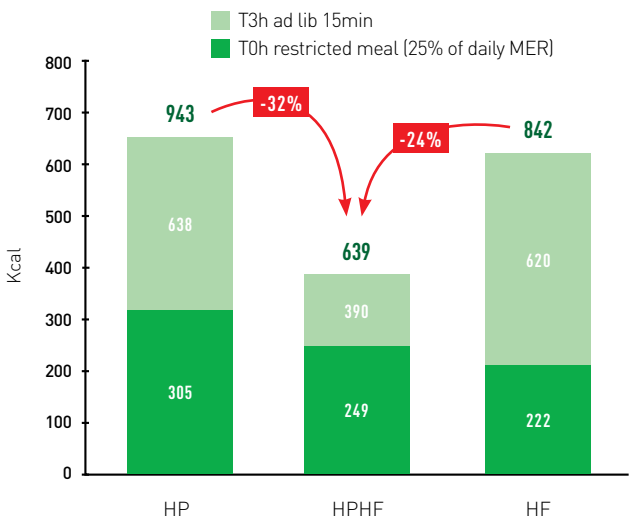
Rate of weight loss



Consumption kinetics



Energy intake 3 hours after a first restricted meal



¹ HPHF: High Protein High Fiber / HP: High Protein / HF: High Fiber

Nutritional strategy for cats

A randomised, single-blinded, positively controlled field trial for weight loss in obese client-owned cats assessed the outcomes of a weight loss programme using 3 different diets: a dry HF diet with specific high-water-binding fibres (A), a mixed ration of the first diet and a pouch of moist diet (B), and a control HF diet without the specific water-binding fibres (C). The main outcomes of weight loss (amount and rate of weight loss, mean energy allocation) did not differ significantly but there were significant differences regarding

the owner's perception of their cat's behaviour and wellbeing. Owners reported an increase in activity with time, with a statistically significant difference only for diet A. A difference was also observed for the owner-reported "hunger score" which was significantly lower with diets A and B. With diet C, cats were vocalising more and seeking more contact with their owner.

For cats the nutritional profile that yields the best results is not HPHF but MPH (Moderate Protein High Fibre), with specific fibres.

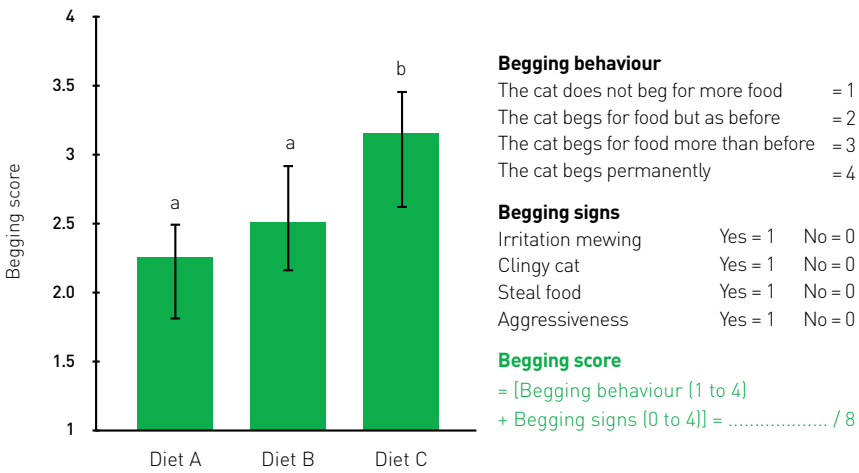
- Weber, M., Bissot T., Servet, E., Sergheraert, R., Biourge V. German, A.J. (2007) A high protein, high fiber diet designed for weight loss improves satiety in dogs. *Journal of Veterinary Internal Medicine* 21;1203-1208. DOI: 10.1892/07-016.1

- German, A.J., Holden, S.L., Bissot, T., Morris, P.J., Biourge, V. (2010) A high protein high fibre diet improves weight loss in obese dogs. *The Veterinary Journal* 183, 294-297. DOI: 10.1016/j.tvjl.2008.12.004

- Bissot, T., Servet, E., Vidal S., Deboise, M., Sergheraert R., Egron, E., Hugonard, M., Heath, S.E., Biourge, V., German, A.J. (2009) Novel dietary strategies can improve the outcome of weight loss programmes in obese client-owned cats. *Journal of Feline Medicine and Surgery* 12, 104-112. DOI: 10.1016/j.jfms.2009.07.003



Assessment of begging during weight loss



Is it beneficial to use dirlotapide in conjunction with a conventional weight loss plan?

Dirlotapide (a selective microsomal triglyceride transfer inhibitor) is licensed for weight loss in obese dogs, but is not designed for use in conjunction with a conventional diet-based plan. A pilot study performed in the ROYAL CANIN® Weight Management Clinic aimed to assess whether using it in combination with a conventional weight loss regime had an additive effect. Five severely overweight dogs (body condition score 9/9, with a median body fat mass of 49.3%), were included. They had all already com-

menced a conventional weight loss programme, but with an excessively slow progression (rate of weight loss < 0.5% per week). Dirlotapide was then administered according to the manufacturer's recommendations. The dogs were kept on the same weight loss diet and the level of energy restriction remained unaltered. They were reweighed every 2-4 weeks, and the dose of dirlotapide was increased when weight loss was beneath 0.3% per week. However, no significant progress was observed over a mean 67 day-period using dirlotapide.

In this dog population, **no additional effect of dirlotapide was seen when combined with a conventional weight loss strategy.** However, further investigations may be necessary to confirm the findings of this pilot study.

German A.J. et al. Adjunctive Dirlotapide therapy during diet-based weight management. A pilot study. 21st ECVIM-CA Congress, Sevilla 2011.

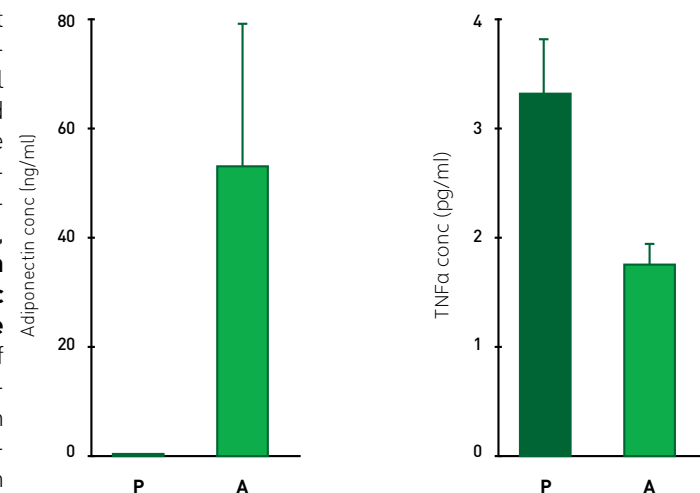
Pathogenesis of obesity-associated diseases

In the past years, one of the main focuses of the ROYAL CANIN® Weight Management Clinic has been on understanding the pathophysiology of obesity and its impact on the metabolism (and health) of companion animals. Once thought to be a passive “lipid storage”, adipose tissue is now recognised as an active endocrine organ that communicates with the brain and peripheral tissues by secreting a wide range of hormones and protein factors, collectively termed adipokines. These adipokines can influence various body systems, and a perturbation of the normal endocrine function is thought to be central in the development of many obesity-associated conditions.

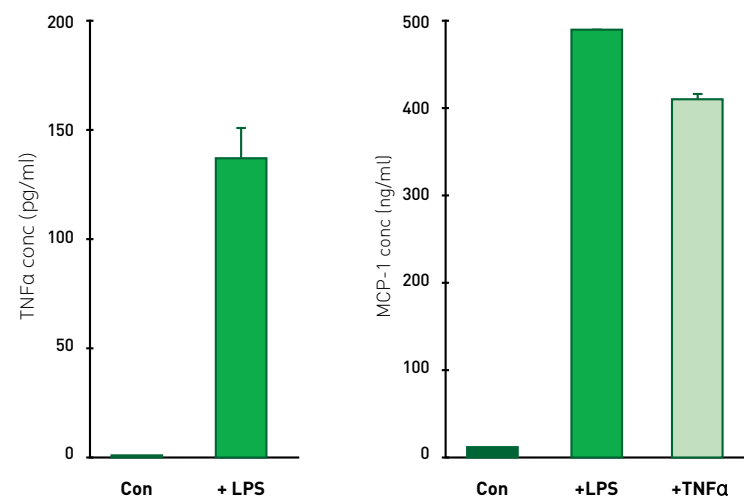
Inflammatory status of obese dogs

A study conducted on 26 obese dogs enrolled in a weight loss programme assessed insulin sensitivity and inflammatory adipokine profiles before and after weight loss. Weight loss induced a significant diminution in white cell counts (mostly neutrophils and macrophages) as well as in the plasma concentration of inflammatory markers TNF- α , haptoglobin and CRP (C-Reactive Proteins), confirming that **weight loss can improve the status of systemic inflammation found in obese dogs**. The plasma concentration of insulin and the insulin:glucose ratio (indirect way to assess insulin resistance) also decreased significantly with weight loss, and both

Adipokine secretion by canine preadipocytes (P) and adipocytes (A)



Effect of inflammatory agents (LPS and TNF α) on adipokine secretion by adipocytes



were positively correlated to the percentage of body fat, confirming **the presence of insulin resistance in obese dogs**. The severity of this insulin resistance correlates with degree of adiposity and **this can be improved with weight loss**. Another study confirmed that **adipocytes are capable of expressing and secreting key adipocyte hormones** (leptin, adiponectin) and **inflammatory adipokines** (TNF- α , IL-6, MCP-1) and are highly sensitive to pro-inflammatory agents. It also showed that the adipokines were also expressed and secreted by pre-adipocytes, while leptin and adiponectin were only secreted by differentiated adipocytes. ■

- German, A.J., Ryan, V.H., German, A.C., Wood, I.S., Trayhurn, P. (2010) Obesity, its associated disorders and the role of inflammatory adipokines in companion animals. *The Veterinary Journal* 185, 4-9. DOI: 10.1016/j.tvjl.2010.04.004

- Ryan, V.H., German, A.J., Wood, I.S., Hunter, L., Morris, P., Trayhurn, P. (2010) Adipokine expression and secretion by canine adipocytes: stimulation of inflammatory adipokine production by LPS and TNF α . *Pflügers European Journal of Physiology* 460, 603-616. DOI: 10.1007/s00424-010-0845-x

- German, A.J., Hervera, M., Hunter, L., Holden, S.L., Morris, P.J., Biourge, V., Trayhurn, P. (2009). Improvement in Insulin Resistance and Reduction in Plasma Inflammatory Adipokines After Weight Loss in Obese Dogs. *Domestic Animal Endocrinology* 37, 214-226. DOI: 10.1016/j.domaniend.2009.07.001

Obese dogs suffer from obesity-related metabolic dysfunction, which has similarities with human « metabolic syndrome »

More recently, a parallel was made with the human metabolic syndrome. **Obesity Related Metabolic Dysfunction (ORMD) was defined as BCS > 7/9 AND the presence of 2 out of 4 metabolic abnormalities** (Triglycerides > 200 mg/dL, Total cholesterol > 300 mg/dL, fasting plasma glucose > 100 mg/dL or previously diagnosed type 2 diabetes mellitus, systolic blood pressure > 160 mmHg). Before weight loss 20% of the dogs met the ORMD criteria, whereas after weight loss none did. There was no difference in fat mass between dogs meeting

the criteria and dogs that didn't. However, dogs with ORMD had greater insulin concentrations than those without ORMD, consistent with the presence of insulin sensitivity. Adiponectin concentrations were also 2 times lower in ORMD dogs, a finding also seen in human metabolic syndrome, and confirming the presence of metabolic derangements. ■

Tvarijonavičiute A, Ceron JJ, Holden SL, Cuthbertson DJ, Biourge V, Morris PJ, German AJ (2014) Obesity-related metabolic dysfunction in dogs: a comparison with human metabolic syndrome



Impact of obesity on kidney function

As new biomarkers become available, knowledge on obesity-related diseases can improve. For example, a recent study used 3 novel biomarkers of renal functional impairment/disease in addition to the traditional markers of chronic kidney disease to assess the impact of obesity and weight loss on the renal function. In this prospective study, an increased urine protein:creatinine ratio (UPCR > 0.5) and microalbuminuria were significantly more frequent in obese dogs (8/27 dogs vs 1/27 after weight loss and 8/27 dogs vs 3/27 after weight loss, respectively). Urea and USG (urine specific gravity) increased after the dogs lost weight whilst UPCR, UAC (urine albumin mg/g of creatinine) and creatinine significantly decreased. A significant decrease upon weight

loss was also seen for the 3 novel biomarkers (homocysteine, Cystatin C and clusterin). These results suggest that **obesity may cause subclinical alterations in the dog's renal function, which improves when the dog loses weight**. This study also identified a **correlation between clusterin concentration before weight loss and the amount of lean tissue lost** during weight loss (the greater the concentration of clusterin, the greater the lean tissue loss). ■

Tvarijonavičiute, A., Ceron, J.J., Holden, S.L., Biourge, V., Morris, P.J., German, A.J. (2013) Effect of Weight Loss in Obese Dogs on Indicators of Renal Function or Disease. *Journal of Veterinary Internal Medicine* 27, 31-38.

Key number

20 % of obese dogs meet Obesity-Related Metabolic Dysfunction criteria

Peculiarities of cats

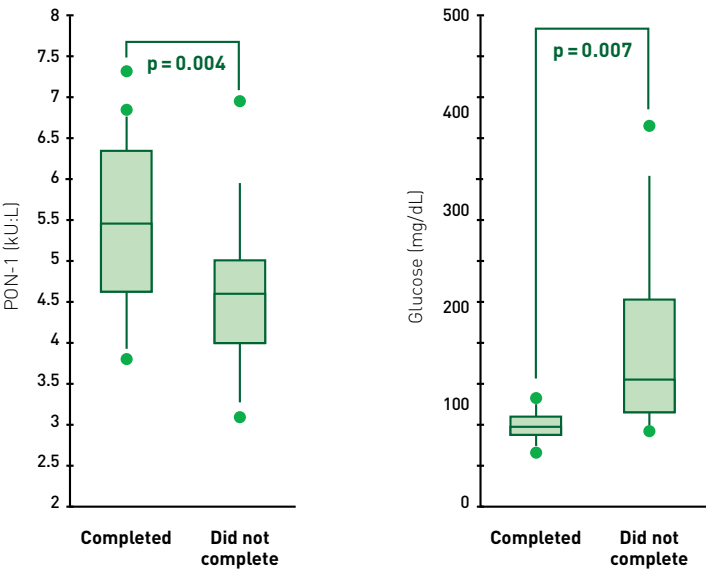
Although metabolic derangements also occur in cats, the pattern is somewhat different from dogs. A 2012 study aiming to better understand the pathophysiological mechanisms of feline obesity, their link to inflammation and their association with co-morbidities (eg insulin resistance) showed that, indeed, cats are not little dogs! 37 overweight client-owned cats enrolled in a weight loss programme were included in this study. Measures included acute-phase proteins, hormones (insulin, IGF-1¹, adiponectin), enzymes (eg PON-1)² related to inflammation and glycaemia. Insulin sensitivity was assessed indirectly by HOMA³ Model Assessment (HOMA)³.

Unlike the pattern in dogs and humans, **inflammatory biomarkers were within the reference range in obese cats**, and no significant changes were seen after weight loss. Conversely, significant alterations in metabolic biomarkers were evident, especially those involved in glucose homeostasis. Notably, weight loss led to an increase in adiponectin and IGF-1 concentrations, whereas insulin and HOMA both decreased. In this study, **cats which failed to reach target weight had lower concentrations of PON-1, adiponectin and IGF-1 and higher glycaemia** before weight loss than those which succeeded. At the current time, the reasons for such

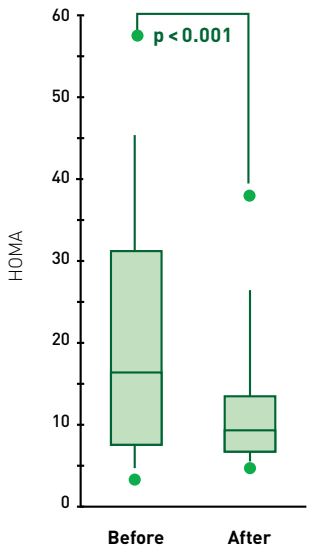
an association are not known and require further study. Most intriguing would be the potential for such molecules to be suitable biomarkers for weight loss follow-up and/or success prognosis. The final intriguing finding from this study was that **adiponectin before weight loss was negatively correlated with the amount of lean tissue loss** (the lower the adiponectin, the greater the loss of lean tissue). ■

Tvarijonaviute, A., Ceron, J.J., Holden, S.L., Morris, P.J., Biourge, V., German, A.J. (2012) Effects of weight loss in obese cats on biochemical analytes relating to inflammation and glucose homeostasis. Domestic Animal Endocrinology 42, 129-141.

Biomarker concentrations before weight loss : comparison between cats failing or completing the weight loss programme



Changes in cats' glucose homeostasis with weight loss



Epidemiology & risk factors for obesity

Season has an impact on food intake in cats

If a seasonal effect on food consumption was well known in livestock, little was known about such an effect in dogs and cats. This retrospective study assessed the consequences of season and month on food intake in 38 adult cats over a 6-year period.

The study was performed in the South of France (Mediterranean climate) between 2004 and 2009. Thirty-eight adult cats of various breeds, age and gender were fed ad libitum, and individual food intake was recorded on a daily basis using electronic weight scales. Cats were housed in closed indoor/outdoor runs. Thirty of them had unlimited outdoor access, and the remaining 8 lived exclusively indoors. Depending on the season, the temperature inside the cattery varied between 18°C and 24°C, and artificial light was provided between 7:30 am and 5:00 pm if natural light was considered insufficient by animal handlers.

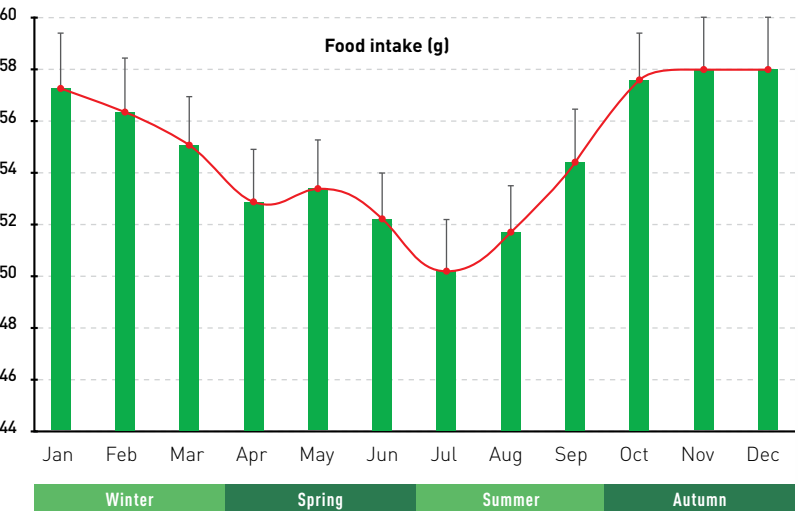
The analysis of recorded food consumption over the 6-year period showed that whatever the year, a seasonal effect was evident, ($p < 0.001$), with three periods of broadly differing intake. Food intake was least in the summer months (e.g., June to August), and greatest during the months of late autumn and winter (e.g., October to February), with intermediate intake in the spring (e.g., March to May) and early autumn (e.g., September). However, a seasonal effect on bodyweight was not recorded.

The analysis of climatic data revealed that periods of peak and troughs in food intake coincided with peaks and troughs in both temperature and daylight length.

Whatever the year, average food intake in summer was 15% lower than food intake in winter. This variation of food intake could be the result of the variation of outside temperatures, differences in daylight duration, and/or hair and coat changes. This seasonal effect in food intake should be properly considered when estimating daily maintenance energy requirements in cats. ■

Serisier S, Feugier A, Delmotte S, Biourge V, German AJ. Seasonal variation in the voluntary food intake of domesticated cats (Felis catus). PLoS One. 2014 Apr 23;9(4):e96071

Month effect on average food intake over the 6-year retrospective study



¹ IGF-1: Insulin Growth Factor 1

² PON-1: Paraoxonase type 1

³ Homeostatis Model Assessment (HOMA) = fasting insulin (μU/ml) x fasting glucose (mg/dl) ÷ 22.5

Growth rate is a risk factor for adult obesity

In human subjects, the risk of becoming overweight in adulthood is largely determined early in childhood. Is this also true for pets? This 8.5-year longitudinal study in 80 cats identified a faster growth rate as a risk factor predicting the likelihood of becoming overweight during adulthood.

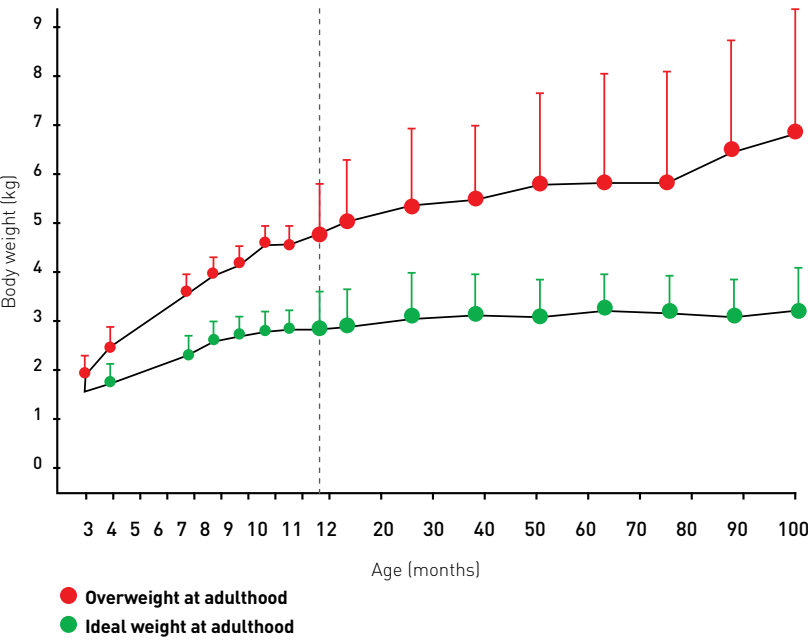
A total of 80 colony cats, fed ad libitum, were studied; various breeds, ages and sex were included, with 36 (45%) being overweight and 44 (55%) being of ideal weight. The effects of various risk factors for being overweight were assessed (inclu-

ding age, sex, neuter status, breed, mean daily food intake, housing status and body weight at 1 year of age), and body weight at 1 year of age was identified as the main significant variable. Given the importance of this factor, changes in body weight from 3 months to 1 year were also assessed where full data was available (16/80 cats). A faster growth rate between 3 months and 1 year of age appeared as a risk factor for being overweight in adulthood, suggesting that the difference between groups at 8.5 years of age originated from growth.

Further investigations are necessary to understand which factors (e.g., genetics, rate of growth, food intake, physical activity...) may be responsible for body weight differences when reaching adulthood. Nonetheless, identifying at-risk cats at an early age, before the onset of obesity, could enable a better targeting of strategies aimed at preventing feline obesity. ■

Serisier, S., Feugier, A., Venet, C., Biourge, V., German, A.J. (2013) Faster growth rate in ad libitum-fed cats: a risk factor predicting the likelihood of becoming overweight during adulthood. Journal of Nutritional Science 2, 2013e11.

Body weight evolution of 16 cats fed ad libitum monitored from 3 months to 8.5 years of age



Key numbers

Cats tend to eat more on winters. Their body condition should be closely watched accordingly.

In cats, a greater bodyweight at one year of age, even in ideal body condition, is a predictive factor for overweight at adulthood.

Tools for assessing obesity in dogs and cats

Can body composition be estimated from photographs?

A digital tool (internet webpage, or smartphone application) where an owner can upload photographs of his/her pet and obtain an estimation of the body composition would definitely help increase awareness about pet obesity and encourage owners to seek for their vet's advice. Two studies performed at the ROYAL CANIN® Weight Management Clinic assessed the feasibility of using photographs to determine body composition in dogs and cats. Photographs taken before and after weight loss from 101 dogs and

47 cats of various breeds, age, and sex, were used. Twelve observers with various levels of experience examined the photographs and estimated the body condition score (iBCS) using 3 different methods:

- iBCS measured: Measurement of abdominal width to thoracic width ratio (A/T ratio)
- iBCS subjective: Semi quantitative examination of visual descriptors of BCS
- iBCS adjusted: A combined approach involving both A/T ratio and visual assessment

Moderate associations with body fat (measured by dual X-ray Absorptiometry) and agreement with actual BCS were seen with all 3 methods, but scores assigned by lay operators were less reliable than for operators with veterinary training. Age, breed, sex, and coat length had no significant effect on iBCS. For all methods, body condition was least likely to be scored correctly in overweight dogs than in dogs that were obese or in normal condition. ■

| Method | iBCS Measured | iBCS Subjective | iBCS Adjusted |
|--------------------------------|---------------|-----------------|---------------|
| Correct BCS assigned CAT study | 48% | 57% | 58% |
| Correct BCS assigned DOG study | 74% | 60% | 70% |

Gant, P., Holden, S.L., Biourge, V., Morris, P.J., German, A.J. (2013) Can you tell how fat a cat is from a photograph? European College of Veterinary Internal Medicine Congress; Liverpool, UK. September 2013.

Gant, P., Holden, S.L., Biourge, V., Morris, P.J., German, A.J. (2013) Can body composition be estimated from photographs? ACVIM Forum; Seattle, USA.



Key fact

Body composition may be estimated accurately from photographs.



III

10 years of expertise in pet obesity: truth and fallacies

True or false?

Adipose tissue is an inert storage deposit

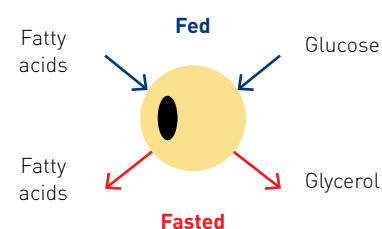
False!

Once thought to be a passive fuel depot, adipose tissue is now recognised as an active endocrine organ secreting a large range of hormones and protein factors called adipokines. Examples include leptin, adiponectin, cytokines (TNF- α , Interleukin 6), chemokines...

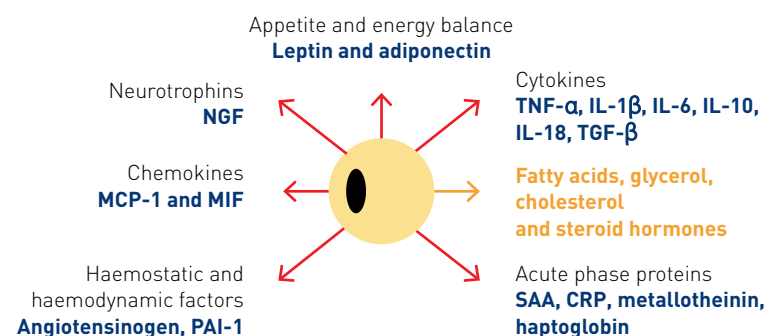
Almost 100 different adipokines have been identified in humans and rodents, and gene expression and protein secretion for a variety of adipokines have also been documented for white adipose tissue in cats and dogs.

These adipokines can influence various body systems, leading to the disruption of the endocrine function. This is thought to be central in the development of many obesity-associated conditions. ■

Inert storage depot



Secretory and endocrine gland



True or false?

Even if the target weight is not achieved, losing a few kilos lost can make a difference

True!

Even if the pet does not reach target bodyweight, making a pet lose some weight is always beneficial. Even a small amount of bodyweight loss is good for the pet's health and well-being, and the benefits are rapidly visible. For instance, research in obese dogs with associated osteoarthritis (Marshall

2010) has shown that noticeable improvement in clinical signs of lameness can be seen even after modest weight loss (from about 6% weight loss, obtained after 8 weeks on average in this study). ■

Marshall, W. G. et al. The effect of weight loss on lameness in obese dogs with osteoarthritis. Vet Res Commun (2010) 34: 241-253

True or false?

Making a pet lose weight is expensive

False!

A ROYAL CANIN® Weight Management Clinic study compared the average costs of food before and during weight loss in dogs, and showed that for most owners, a weight management regimen using a therapeutic diet is cost neutral.

When taking into account the main meal and all the treats and extras fed before starting a weight management programme, the average daily food cost before weight loss is not significantly different from the food cost over the weight loss plan! ■

True or false?

The job is done when the pet reaches its target bodyweight

False!

Once a pet has reached its target bodyweight, the risk of weight rebound is still high. Long-term follow-up studies conducted at the ROYAL CANIN® Weight Management Clinic have shown that after weight loss, the energy requirements to maintain stable bodyweight remain low (typically

only about 10% higher than the energy requirements at the end of weight loss). As a consequence, continuing to feed a weight management diet during the maintenance phase can limit the risk of relapse. A study comparing dogs switched to a standard maintenance diet with dogs kept on their

weight loss diet showed a significant reduction in weight rebound with the latter (81% versus 18% respectively). ■

German, A.J., Holden, S.L., Morris, P.J., Biourge, V. (2012) Long-term follow-up after weight management in obese dogs: The role of diet in preventing regain. Veterinary Journal 192, 65-70.

German, A.J., Holden, S.L., Mather, N.J., Morris, P.J., Biourge, V. (2011) Low Maintenance Energy Requirements of Obese Dogs After Weight Loss. British Journal of Nutrition, 106, S93-S96.



True or false?

Some weight loss diets can change the pet's gene expression

Not completely true!

A genetic profile analysis can give a "mapping" of gene expression, but experts don't yet know how to interpret this mapping or to identify what is really biologically significant. What we currently know is that obesity affects the gene

expression profile and that losing weight helps this gene expression profile to return to "normal". Some pet food manufacturers use this argument extensively to support their diets but, in fact, the modified gene expression profile may not be

due to a specific diet, but most likely to the fact that the dogs lost weight. We can assume that any diet that makes pets lose weight will have the same effects on gene expression. ■

True or false?

High carbohydrate diets are an important risk factor in the development of obesity and diabetes mellitus in cats

False!

Although it has been hypothesized that feeding high starch diets over long periods may lead to beta cell destruction and the subsequent development of diabetes mellitus, current data have led nutritionists to reject this theory. Epidemiological data do not support the hypothesis, and multiple studies have shown that neither resting glucose concentration nor insulin sensitivity is adversely affected by high starch diets in healthy cats.

Properly processed starches and complex carbohydrates are efficiently digested and metabolised by healthy cats, providing glucose for body cells.

The increasing prevalence of diabetes mellitus is more likely due to obesity and ageing, and the major risk factor for obesity is not the carbohydrate content of the diet but rather inadequate feeding patterns (i.e. excess energy intake) and an inactive lifestyle.

However, for cats suffering from diabetes mellitus, dietary management is essential and low-carbohydrate high-protein diets have been shown to improve glycaemic control. ■



True or false?

Weight loss can be achieved successfully in a few weeks

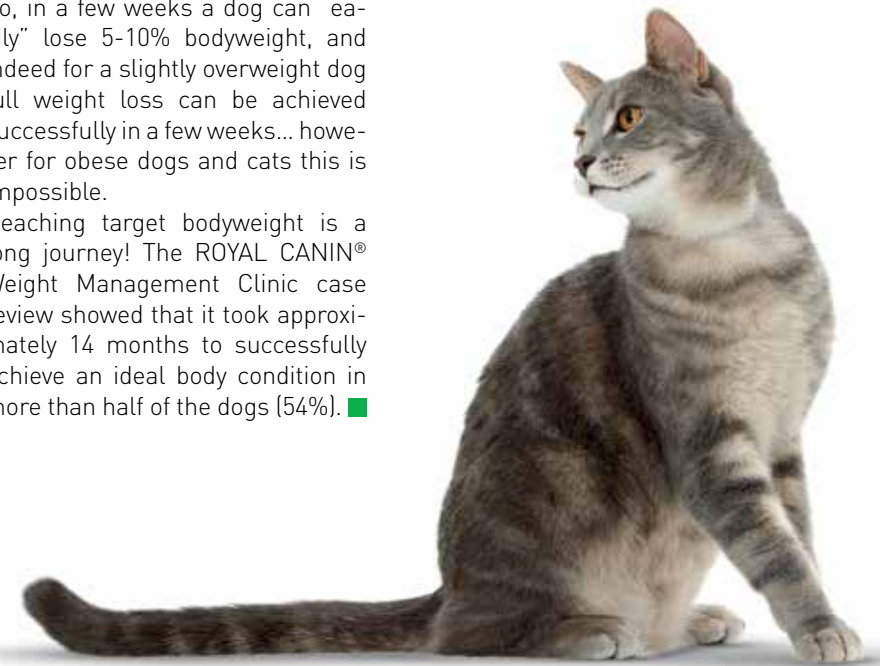
False! ... but sometimes true

Duration of weight loss depends mostly on the amount of weight the pet has to lose (not to mention the owners' commitment and all the possible causes of regimen failure).

A recent review of 149 dog cases followed at the ROYAL CANIN® Weight Management Clinic showed that the kinetics of weight loss were highly variable according to the stage of the weight management regimen: the rate of weight loss is generally high at the beginning of the program (median 1.2% SBW¹/week, up to 3% the 1st month) but progressively decreases as the cumulative percentage of weight loss increases (median 0.7% SBW/week, up to 2% the 3rd month).

So, in a few weeks a dog can "easily" lose 5-10% bodyweight, and indeed for a slightly overweight dog full weight loss can be achieved successfully in a few weeks... however for obese dogs and cats this is impossible.

Reaching target bodyweight is a long journey! The ROYAL CANIN® Weight Management Clinic case review showed that it took approximately 14 months to successfully achieve an ideal body condition in more than half of the dogs (54%). ■



True or false?

Cats are similar to dogs regarding obesity and weight loss (WL)

False!

- **Differences in health issues related to obesity:**

obese dogs are in a state of chronic inflammation (net increase of inflammation biomarkers), which is not seen as frequently in cats... and insulin resistance due to obesity often leads to diabetes mellitus in obese cats whereas in obese dogs insulin resistance often remains subclinical.

- **Nutritional strategy:**

protein has a satietogenic effect in dogs while in cats it tends to promote food intake, so nutritional profiles to promote satiety are different in dogs and cats (Moderate Protein High Fibre diet for cats vs. High Protein High Fibre diet for dogs)

- **Expected weight loss rate to achieve healthy weight loss** (i.e. fast enough, with minimal lean mass loss) is lower in cats than in dogs : cats rarely lose weight faster than 1% SBW¹/week, when dogs can lose up to 2-3% SBW/week in the first weeks.

- **A possible deadly outcome:**

an obese cat that becomes anorexic can develop hepatic lipidosis, which is fatal if not treated (and sometimes despite treatment) whereas this is hardly ever seen in dogs. ■

¹ SBW: Starting Body Weight

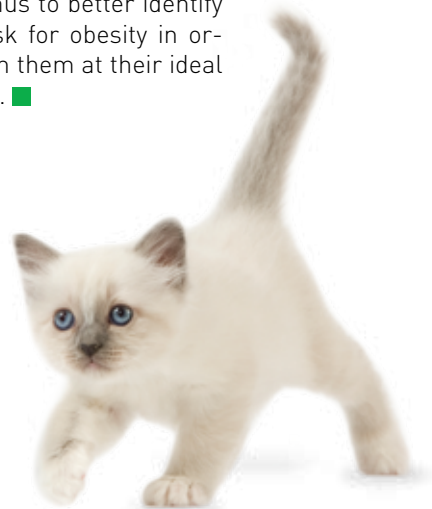
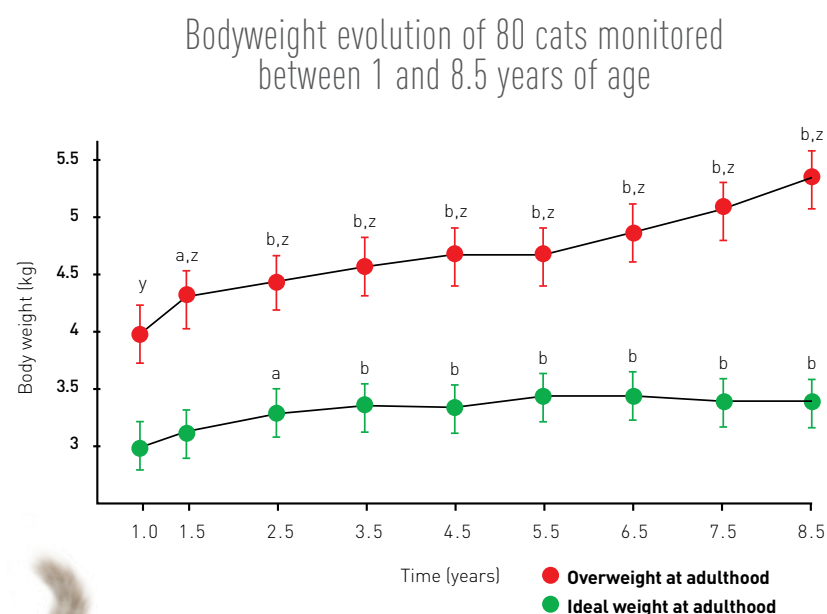
Future research

what will the next 10 years bring?

Early-life risk factors for obesity

Recently, ROYAL CANIN®, in partnership with the ROYAL CANIN® Weight Management Clinic, conducted an 8-year retrospective study in 80 cats of 14 different breeds (Serisier, 2013). The results clearly showed that feline obesity at adulthood originated from the early life period.

Thanks to these first findings we want to further investigate the early-life factors of obesity. These may be zootechnical, physiological, dietary, genetic and, most probably, multifactorial. Hopefully, the results will help us to better understand the development of pet obesity, and thus to better identify the pets at risk for obesity in order to maintain them at their ideal body condition. ■



Focus on the feline species

To date, a large part of the studies conducted at the ROYAL CANIN® Weight Management Clinic involves the canine species. In the coming years, an increasing focus will be made on cats and their peculiarities when it comes to obesity.

Current findings have already shown specificities in terms of pathogenesis, associated diseases, dietary management as well as weight loss patterns, that would clearly require additional research. ■



Impact of faecal microbiota

Increasing attention is being paid to the commensal microbiota, as it regulates multiple physiological mechanisms and has been shown to be involved in the development of human obesity. Naturally, one of the future focuses of pet obesity research will be the impact of faecal microbiota.

In a recent study comparing faecal microbiota in lean and obese pet dogs, no major shifts in the faecal microbiota (like those seen in mice and humans) was highlighted.

The only significant difference was the greater abundance of genus *Roseburia* (order Clostridiales) in obese dogs. In the same study, when comparing the faecal microbiota of dogs fed the same diet ad libitum vs. restricted, Clostridiales increased more in dogs fed ad libitum. Further studies with better controlled environmental factors, a standardised methodology and

analyses that go beyond the phylum level might allow a better understanding of the role of the intestinal microbiota in obesity development in dogs. ■

Handl, S., German, A.J., Holden, S.L., Dowd, S.E., Steiner, J.M., Heilmann, R.M., Grant, R.W., Swanson, K.S., Suchodolski, J.S. (2013) Faecal microbiota in lean and obese dogs. *FEMS Microbiology Ecology* 84, 332-343.

New weight management diets

Besides this research we will obviously continue to develop new nutritional solutions that will help veterinarians to prescribe efficient diets to facilitate weight loss in dogs and cats and to eventually stabilise their ideal bodyweight. We are currently investigating new technologies, functional ingredients and weight loss plans to assess their interest in weight management. ■



Scientific References:

10 years of research performed at the ROYAL CANIN® Weight Management Clinic

2015

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Deagle, G., Holden, S.L., Biourge, V., Morris, P.J., German, A.J. (2014). Long-term follow-up after weight management in obese cats. *Journal of Nutritional Science* 3, e25. doi:10.1017/jns.2014.36.

Serisier, S., Pizzagalli, A., Leclerc, L., Feugier, A., Nguyen, P., Biourge, V., German, A.J. (2014). Increasing volume of food by incorporating air reduces energy intake. *Journal of Nutritional Science* 3, e59.

Rolph, N.C., Noble, P.J.M., German, A.J. (2014). How often do primary care veterinarians record the overweight status of dogs? *Journal of Nutritional Science* 3, e58. doi:10.1017/jns.2014.42.

Eastland-Jones, R.C., German, A.J., Holden, S.L., Biourge V., Pickavance, L.C. (2014). Owner misperception of canine body condition persists despite use of a body condition score chart. *Journal of Nutritional Science* 3, e45

Bermingham, E.N., Thomas, D.G., Cave, N.J., Morris, P.J., Butterwick, R.F., German, A.J. (2014) Energy requirements of adult dogs: A meta-analysis. *PLoS ONE* 9, e109681

2013

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