Long-term follow-up after weight management in obese cats*

Gabrielle Deagle1, Shelley L. Holden1, Vincent Biourge2, Penelope J. Morris3 and Alexander J. German1†

1Department of Obesity and Endocrinology, Department of Ageing and Chronic Disease, University of Liverpool, Liverpool, UK
2Royal Canin Research Center, Aimargues, France
3The WALTHAM Centre for Pet Nutrition, Freeby Lane, Waltham-on-the-Wolds, Melton Mowbray LE14 4RT, UK

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Abstract

Feline obesity is a prevalent medical disease and the main therapeutic strategy is dietary energy restriction. However, at present there are no data regarding long-term outcome in this species. The purpose of the present study was to investigate if, as in other species, some cats regain weight following successful weight loss, and to identify any influencing factors in a cohort of client-owned cats with naturally occurring obesity. Twenty-six cats were included, all of which had successfully completed a weight management programme. After weight loss, cats were periodically monitored. The median duration of follow-up was 954 d (72–2162 d). Ten cats (39 %) maintained their completion weight (±5 %), four (15 %) lost >5 % additional weight and 12 (46 %) gained >5 % weight. Seven of the rebounding cats (58 %) regained over 50 % of their original weight lost. Older cats were less likely to regain weight than younger cats (P = 0.024); with an approximately linear negative association between the cat’s age and the amount of weight regained (Kendall’s τ = −0.340, P = 0.016). Furthermore, cats whose energy intake during weight loss was greater were also more likely to regain weight (P = 0.023). When the characteristics of weight regain in cats were compared with those from a similar cohort of dogs, cats that rebounded were more likely to regain >50 % of the weight they had lost. These results suggest that weight regain, after successful weight loss, is common in obese cats, and that young cats (<7 years of age) are most at risk.

Key words: Weight loss: Overweight: Feline nutrition: Weight regain

Feline obesity is a common medical disorder and predisposes to other diseases including diabetes mellitus1. Management of an overweight cat involves shifting the positive energy balance through three key components: exercise, dietary modification and owner education. Although previous studies, which use these components, have demonstrated the success of weight management strategies1,2, data are more limited on long-term outcome.

Considerable effort is required to achieve successful weight loss in cats, and to reach target weight but, arguably, maintaining that target weight is just as important. Long-term success with dietary management is poor in human subjects, with regain being common after initial weight loss. Indeed, in one meta-analysis, 29–64 % of participants regained all of the weight they originally lost and some gained additional weight3. Some studies have suggested a decreased post-weight-loss resting metabolic rate, but evidence is contradictory: a review of 12 studies determined the relative resting metabolic rate of the formerly obese group to be 5-1 % less than control6, while another study identified only a transient hypothyroid–hypometabolic state5. In dogs, studies have identified a decreased post-weight-loss maintenance energy requirement, which had been suggested to explain the tendency for weight rebound in this species6–7. Weight regain is also seen in obese pet dogs that successfully lose weight, with one recent clinical study suggesting that almost half of dogs that reach target subsequently regain weight8. However, although weight regain has been demonstrated in experimental weight loss studies in cats9, to the authors’ knowledge, no published data exist regarding the issue of

†Corresponding author: A. J. German, fax + 44 151 795 6101, email ajgerman@liv.ac.uk

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regain after weight loss in obese pet cats. Therefore, the purpose of the present study was to investigate if obese, client-owned, cats maintain their weight following a successful weight loss programme, and to identify factors associated with the tendency to regain weight.

Methods and materials

Animals

Obese cats that had successfully completed a weight management programme at the Royal Canin Weight Management Clinic, University of Liverpool, were eligible for inclusion. All cases were recruited, investigated, and managed by the same veterinarian (A. J. G.) and veterinary nurse (S. L. H.). Cats were eligible if their weight loss had commenced between December 2004 and July 2012, and had completed by February 2013. Additional eligibility criteria were that the cats needed to have remained systemically well during their weight loss and follow-up. This was determined by the absence of clinical signs suggestive of another systemic disease, and the absence of significant abnormalities on clinicopathological analyses (routine haematology, serum biochemistry and urinalysis), throughout the period of weight loss and during follow-up. In addition, owners had to be contactable at the time of follow up. The study protocol adhered to the University of Liverpool Animal Ethics Guidelines and was approved by both the University of Liverpool Research Ethics Committee and the WALTHAM ethical review committee. The owners of all participating animals gave informed written consent.

Weight loss phase

Complete details of the weight loss regime have been previously described[8]. Briefly, calibrated electronic weigh scales were used for all weight measurements, while fan-beam dual-energy X-ray absorptiometry was used to assess body composition before and after weight loss[9]. A tailored weight loss programme was devised for each cat, based upon dietary management (starting allocation 146–167 kJ/kg (35–40 kcal/kg) target weight/d), and lifestyle alterations. Depending upon individual preference, a high-protein high-fibre dried diet (Satiety Support; Royal Canin, Aimargues, France), a high protein dried diet (Obesity Management DP 42; Royal Canin), and/or a high protein diet (Obesity Management S/O, Royal Canin) was used. Body weight was rechecked every 14–28 d, and the weight programme was adjusted, as required to maintain steady weight loss. All adjustments to the programme were made by the same veterinary nurse (S. L. H.). On the request of the owner, one cat did not have a repeat dual-energy X-ray absorptiometry performed.

Weight maintenance phase

A repeat of the weight loss phase was undertaken by an identical veterinary nurse (S. L. H.). In the event of a weight gain exceeding 2% of body weight, the diet was adjusted again and the cat was reweighed within 7 d. If the weight gain was less than 2% but more than 1%, the diet remained unchanged and the cat was reweighed within 14 d. If the weight gain was less than 1%, the diet remained unchanged and the cat was reweighed within 28 d, and the weight programme was adjusted, as required to maintain steady weight loss. All adjustments to the programme were made by the same veterinary nurse (S. L. H.). On the request of the owner, one cat did not have a repeat dual-energy X-ray absorptiometry performed.

Weight maintenance food of their choice, both fed to maintain bodyweight. Whichever option they chose, follow-up was similar: for cats on the diet food, at each check, food intake was increased by 5–10 % each visit, until weight loss stabilised; for cats switched to a different diet, the weight loss food was gradually substituted over 3–7 d for an equivalent amount (on an energy basis) weight loss food. For cats on either food, once stable weight was achieved, monitoring continued less frequently, and the frequency of rechecks ranged from monthly to biannually. However, additional support was offered as needed for the case, either by telephone, email or in person.

Long-term follow-up

Two of the authors (G. D. and S. L. H.) gathered all of the follow-up information. In the early 2013, a review of all cats, that had successfully completed their weight loss programme and reached target weight, was conducted. First, the referring veterinary practice was contacted to determine whether or not cats were still registered and were still alive. If cats were still alive an attempt was then made to contact the owner to organise a reweighing. If reweighing was not possible, data from last follow-up were used. Two cats had recently developed unrelated illnesses and, as a consequence, their last healthy weight on record was used. Owners were also contacted to discuss current feeding practices. Attempts to contact owners extended over two months, and at least three attempts were made to contact each client. All except one provided current feedback. The variations of time between completion of the weight loss programme and follow-up were largely dependent on the original case enrolment date. For the owners that were successfully contacted, information was gathered on current feeding practices, either by phone or in person. Rather than using a standardised questionnaire, open questions were asked in order to gather as much detail as possible, and points of confusion were clarified as required. An attempt was made to gather the details regarding the food fed as main meal and how much, the method of measuring food portions (e.g. use of electronic scales, measuring cups, or simply estimating portions by eye), feeding of additional food (e.g. table scraps and treats), and whether a diary record was being used. Based upon the data gathered, cats were classified as ‘regulated’ (whereby the maintenance food remained the same, food portions were measured accurately (i.e. with electronic scales), and diary records were maintained) or ‘unregulated’ (whereby different foods were used, portion size was measured in another way (commonly by estimation), and diary records were not maintained).

Data handling and statistical analysis

All data are expressed as median (range) except where indicated. Weight regain was quantified by the percentage change from completion weight. Cats were assigned to one of three categories: ‘maintained target weight’ (M), if follow-up weight remained within 5% of completion weight; ‘lost further weight’ (L) or ‘regained weight’ (R) when follow-up weight was >5% below or >5% above completion weight, respectively[8].
Prior to weight loss, none of the cats had significant abnormalities on routine haematological analysis, serum biochemical analysis, and urinalysis. The median percentage weight loss was 19.8 (7.3–37.4 %) of starting body weight at a median rate of 0.6 % starting body weight per week (0.2–1.3 %) over a period of 204 d (91–796 d).

Weight maintenance phase

The median duration of follow-up was of 954 d (72–2162 d). Ten cats (39 %) maintained their completion (target) weight, four (15 %) lost more weight, and the remaining 12 (46 %) regained weight. The median change from completion weight was 2.0 % (−17.5–62.8 %), which represents 7.7 % (−51.4–427.3 %) of the original weight lost. Seven cats had regained over 50 % of their original weight lost.

Factors associated with regain

Table 2 summarises the results from the simple and multiple regression analyses of variables associated with weight regain. On simple regression analysis, variables identified as P < 0.3 were age of cat at both enrolment and follow-up (P = 0.082 and 0.128, respectively), mean energy intake during weight loss (P = 0.101), having other cats in the household (P = 0.169) and dietary control during maintenance (P = 0.076). However, on multiple regression analysis, only age at enrolment and mean energy intake during weight loss were significant: older cats were less likely to regain weight than younger cats (OR 0.95; 95 % CI 0.92, 0.99; P = 0.024), while cats that lost weight with a greater mean energy intake were more likely to regain weight (OR 1.44; 95 % CI 1.05, 1.96; P = 0.023). To determine whether older cats were less likely to rebound was due to them having been followed for a shorter period, follow-up duration was compared between young (<7 years of age) and older cats (≥7 years of age): no difference was noted between groups (P = 0.751).

A comparison of weight rebound in cats and dogs

Fisher’s exact test demonstrated no divergence between tendency to rebound in cats vs. dogs (P > 0.9999) indicating both species had a similar tendency to regain weight following weight loss. Furthermore, the weight change from target weight (P = 0.821) and the percentage of original weight loss regained (P = 0.517) were not different between dogs and cats. However, when the weight regain was expressed relative to the amount originally lost, cats were more likely to regain >50 % of their original weight loss than dogs (P = 0.0497).

Discussion

Although weight regain after initial loss is well documented in obese human subjects and dogs, the present study is the first to provide an insight into long-term outcomes of formerly obese pet cats following successful weight loss. As with pet dogs, regain occurred in almost half of the cats originally reaching their target weight. Regarding amount of weight regain, cats are intermediate between dogs, where approximately a
Status at follow-up: Maintained weight (10, 39%), lost further weight (4, 15%), regained weight (12, 46%).

![Image](journals.cambridge.org/jns)

### Table 1. Summary of cat characteristics and outcomes of weight loss and follow-up (n = 26)

| Criterion | Group summary |
|-----------|---------------|
| Breed     | DSH (24), BSH (1), Selkirk Rex (1) |
| Sex       | Neutered male (18), Neutered female (8) |
| Age at enrolment (months) | 84 (16–156) |
| Age at follow-up (months) | 132 (59–214) |
| Starting bodyweight (kg) | 6.88 (5.45–10.30) |
| Starting body fat (%) | 32 (17–45) |
| Mean energy restriction for weight loss (kcal) | 31.08 (20.78–42.16) |
| Duration of weight loss (days) | 204 (91–796) |
| Bodyweight at end of weight loss (target) (kg) | 5.38 (3.95–7.35) |
| Mean rate of weight loss (%) | 0.6 (0.2–1.3) |
| Weight loss (%) | 19.8 (7.3–37.4) |
| Change in lean mass (%) | –6.4 (–21.5–17.5) |
| Other cats in household | 16 yes, 10 no |
| Dogs in household | 9 yes, 17 no |
| Indoor–outdoor status | 3 indoor only, 23 indoor with outside access |
| Dietary control during maintenance | Regulated (17), Unregulated (8), Unknown (1) |
| Bodyweight at follow-up (kg) | 5.60 (3.50–10.50) |
| Duration of follow-up (day) | 954 (72–2162) |
| Change from completion (target) weight (%) | 2.0 (–17.5–62.8) |
| Regained weight (kg) | 0.1 (–0.9–4.1) |
| Original weight loss regained (%) | 7.7 (–51.4–427.3) |
| Status at follow-up | Maintained weight (10, 39%), lost further weight (4, 15%), regained weight (12, 46%) |

All data are expressed as median (range).

| Diet used for weight loss* | (1) a high-protein and -fibre dried diet (Satiety Support; Royal Canin, Almargues, France), (2) a high-protein dried diet (Obesity Management D5; Royal Canin) (3) a high-protein diet (Obesity Management S/O, Royal Canin). When two diets are indicated (e.g. 1&3) a combination of the two were used. |
| Duration of follow-up (day) | 1–30 (20–75) |

### Table 2. Results of simple and multiple logistic regression analysis determining factors involved with tendency to rebound (n = 26)

| Logistic regression | OR 95% CI | P |
|---------------------|----------|---|
| Initial model | | |
| Age at enrolment (months) | 0.98 0.95 1.00 | 0.082 |
| Age at follow-up (months) | 0.98 0.96 1.00 | 0.128 |
| Sex | 0.80 0.15 4.24 | 0.793 |
| Starting bodyweight (kg) | 1.09 0.58 2.03 | 0.789 |
| Bodyweight at completion of weight loss (target) (kg) | 0.91 0.32 2.59 | 0.854 |
| Mean energy restriction for weight loss (kcal) | 1.17 0.97 1.42 | 0.101 |
| Diet used for weight loss – wet/dry | 1.00 0.21 4.67 >0.999 |
| Diet used for weight loss – fibre | 0.60 0.11 3.3 | 0.557 |
| Starting body fat (%) | 0.94 0.84 1.06 | 0.315 |
| Duration of weight loss (days) | 1.00 1.00 1.01 | 0.509 |
| Mean rate of weight loss (%) | 0.19 0.01 3.29 | 0.256 |
| Weight loss (%) | 1.01 0.92 1.12 | 0.81 |
| Change in lean mass (%) | 0.95 0.87 1.04 | 0.285 |
| Other cats in household | 0.30 0.05 1.67 | 0.169 |
| Dogs in household | 1.07 0.20 5.77 | 0.940 |
| Indoor–outdoor status | 0.54 0.43 6.89 | 0.640 |
| Dietary control during maintenance | 5.50 0.84 36.20 | 0.076 |
| Duration of follow-up (days) | 1.00 1.00 1.00 | 0.994 |
| Final model | | |
| Age at enrolment (months) | 0.95 0.92 0.99 | 0.0236 |
| Mean energy restriction for weight loss (kcal) | 1.44 1.05 1.96 | 0.0233 |

For explanation of the factors, please see the legend for Table 1.
reason for this is not known and, in fact, it is difficult to identify a plausible explanation for such an association; instead, an indirect association might be more likely, namely an association with a confounding variable. One possibility would be if degree of energy restriction during weight loss were a proxy measure for poor compliance (i.e. due to feeding extra food). Of course, such a mechanism is highly speculative, and further investigations would be needed, examining a greater number of variables.

A previous study in dogs had demonstrated that using a standard maintenance diet in the post-weight-loss period increases the risk of weight regain(8). Unfortunately, it was not possible to examine this effect in the cats of the present study because there was a greater variability in the food fed, and many owners did not maintain an accurate record. Instead, therefore, we examined the effect of close monitoring, by comparing those owners who closely regulated their cat’s intake (i.e. by accurately measuring food portions, not giving table scraps or treats, and maintaining records) with those who had not. Although simple logistic regression analysis suggested an effect, this factor did not remain in the final multiple regression model. Further work is recommended to determine the effect of post-weight-loss dietary management in a larger population of obese cats.

The findings in the present paper should be interpreted with caution due to a number of study limitations. First, although the obesity was naturally occurring in all cats, a referral population was studied, which might not be fully representative of the population of cats presenting to a first opinion practice. However, the advantage of using a referral population was the ability to conduct a more detailed case assessment, for example using dual-energy X-ray absorptiometry for body composition analysis, as well as more consistent weighing and monitoring during the programme, by a full-time veterinary nurse. A second limitation is potential bias, from the fact that this was a non-randomised cohort study. Thus, it is possible that an unmeasured confounding factor was responsible for the effects on regain.

A third concern was the fact that data on feeding practices after weight loss were limited. In a similar recent study, in dogs(8), more detailed follow-up records were available. Also, since we relied on owners to provide information on feeding practices, accuracy of the data cannot be ensured. Future prospective studies should concentrate on recording more data from the weight maintenance phase to improve our understanding of the factors leading to weight regain.

A final limitation was the method used to determine the significance of any weight change after weight loss. We adopted a similar approach to that used in a recent dog study(8), and defined limits in which deviation of body weight was acceptable after the weight loss period had been completed. This approach takes into account weigh scale inaccuracies and natural fluctuations in body weight that might result from differences in gut fill and hydration status(8). The limit of ±5 % of target weight was applied, because this represents approximately half a unit on a nine-integer body condition score scale(12,13), so that any difference is unlikely to be noted on a physical examination. Although it was assumed that weight fluctuations within this range should not be clinically relevant(8), we cannot be absolutely certain of this. Similarly, we cannot be certain that regain >5 % of the target weight invariably has clinical consequences. Thus, further studies could be considered to determine acceptable limits for weight fluctuation in obese cats after weight loss, such that quality of life is maximised during both the short- and long terms.

**Conclusions.** The present study has demonstrated that almost half of obese client-owned cats will regain weight following a successful weight loss programme, with a large proportion regaining more than half of the original weight loss. Weight regain is most likely in younger cats. These findings highlight the importance of continuing to monitor cats after weight loss is completed to ensure that the health benefits of weight loss are maintained.

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