

# Intermittent Caloric Restriction: A New Way to Feed Cats for Weight loss

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## Abstract

The objective of this study was to compare the effects of continuous caloric restriction (CCR) and intermittent caloric restriction (ICR) on weight loss in overweight cats. The cats in the CCR group were fed 75% of their maintenance energy requirement (MER) for six months, while the cats in the ICR were fed 75% of their MER during the first two weeks and 100% of their MER during the second two weeks of the 12-month study. Based on equal caloric restriction, the ICR was more effective than the CCR in promoting loss of body fat and percentage of body fat.

Obesity has become a major health issue in cats, and it is estimated that about 25 to 40% of adult cats are either overweight or obese and about 50% of cats between 5 and 10 years old are overweight or obese.<sup>1,2</sup> Obesity in cats increases the risk of many chronic diseases including dermatopathy, diabetes mellitus, gastrointestinal disease, hepatic lipidosis, neoplasia, oral disease, and urinary tract diseases.<sup>1,2</sup> Known risk factors for overweight and obesity include middle age, spaying/neutering, genetics (breed), and indoor dwelling.<sup>2,3</sup>

Dietary treatment of obesity in cats has focused on continuous caloric restriction to promote weight loss.<sup>4</sup> There are two main adverse effects of CCR. First, loss of lean-body mass appears to be inevitable during CCR-induced weight loss. The levels of calorie restriction affect weight-loss rate and body composition in cats. When cats were fed 60% of their MER with weight loss at a rate of 1% per week for 18 weeks, 90% of the weight loss came from body fat and about 8% was from lean-body mass.<sup>5</sup> However, when cats were fed 45% of their MER for 18 weeks with a weight-loss rate of 1.3% per week, loss of lean-body mass was increased to 19% of the total weight loss, and about 80% of the weight loss came from body fat.<sup>6</sup> Another adverse consequence of CCR is that cats respond and lower their energy expenditure. Villaverde, et al.<sup>7</sup> reported that when adult obese cats were maintained on 60% MER to promote weight loss, the cats lowered their energy expenditure from 1337 ±50.6 kJ/d (baseline) to 1025 ±39.6 kJ/d during weight loss. Reduced energy expenditure during weight loss makes

## Glossary of Abbreviations

**ADF:** Alternate-Day Fasting

**CCR:** Continuous Caloric Restriction

**ICR:** Intermittent Caloric Restriction

**mADF:** Modified Alternate-Day Fasting

**MER:** Maintenance Energy Requirement

**QMR:** Quantitative Magnetic Resonance

it harder for obese cats to further lose body fat and much easier for the cats to regain their lost body fat after weight loss. This is the one reason why pets and even people regain their lost body weight after weight loss.<sup>7</sup> Therefore, there is an urgent need to develop a better weight-loss program that can either prevent or reduce the decline in energy expenditure during weight loss.

Intermittent caloric restriction has been extensively studied for its benefits in delaying aging and enhancing life span,<sup>8</sup> delaying or preventing cancer incidence,<sup>9, 10, 11, 12</sup>

ameliorating cognitive impairment in a mouse model of Alzheimer's disease,<sup>13</sup> and protecting the vascular systems of the heart and brain.<sup>14</sup> In addition, it is difficult for many people to adhere to a CCR program due to the necessity of reduction in daily caloric intake for extended periods of time.<sup>15</sup>

Two types of ICR programs have been developed for people to increase adherence to weight-loss programs.<sup>16, 17, 18</sup> The first ICR program is called alternate-day fasting (ADF), which consists of repeats of a 24-hour phase of *ad libitum* food intake and a 24-hour phase of complete fasting.<sup>16, 17</sup> The second ICR regimen is called modified ADF (mADF), which is the same as ADF except the 24-hour complete fast is replaced with a 24-hour phase of caloric reduction.<sup>18</sup> Varady, et al.,<sup>19</sup> tested the effectiveness of mADF in promoting weight loss in obese people in an eight-week weight-loss study, and subjects during the 24-hour phase of caloric reduction consumed 25% of their baseline caloric requirement. At the end of the study, both body weight and body fat were significantly reduced compared with baseline, indicating that mADF was effective in promoting weight loss in obese people. Recently, Harvie, et al.,<sup>20</sup> compared another ICR program (5+2 ICR) with a 25% CCR program in a six-month weight-loss study in overweight or obese premenopausal women. Subjects in the CCR program consumed 75% of their baseline caloric requirements, i.e., 25% restriction. Subjects in the 5+2 ICR group consumed 25% of their baseline caloric requirements on two consecutive fasting days per week, and then 100% of their baseline caloric requirements during the remaining five days of the week. The 5+2 ICR program resulted in an average of 25%

caloric reduction per day. At the end of the study, subjects in both groups lost comparable amounts of body weight, indicating that both methods were equally effective in promoting weight loss in people.

The objective of this study was to compare the effect of an ICR weight-loss regimen with a traditional CCR weight-loss program in overweight cats.

## Materials and Methods

### Cats, Housing and Diet

A total of 28 cats that had become obese/overweight naturally, with a body condition score (BCS) of 7 or over, were recruited into the study. The ages ranged between 2 and 12 (mean 7.9±0.6) years at the start of the study. The study protocol was approved by the Nestlé Purina PetCare Animal Care Committee and complied with the guidelines of the U.S. Department of Agriculture and with Nestlé Purina's animal welfare guidelines. The cats were housed either in individual condos or within groups, but were fed individually. Housing temperature (72 ± 4 oF ) and humidity (50% ± 10%) were kept relatively constant by automated temperature control, continuous ventilation (12 air changes per hour), and a natural light/dark cycle of 14h:10h.

A high-protein, low-fat weight-loss diet was the only diet for all cats in this study (Table 1).

### Baseline MER and Body Composition and Group Allotment

Each cat's baseline MER was estimated as 60 Kcals per kilogram of body weight, then adjusted based on the amount of weight gain or weight loss after one week of feeding, assuming that most of the weight change was fat. So, the adjusted

baseline MER for cats with weight gain = the initial calculated MER - ( g of weight gain per day x7.92). The adjusted baseline MER for cats with weight loss = the initial calculated MER + ( g of weight loss per day x7.92).

After the MER for each cat was determined, the body composition of the cats was determined by quantitative magnetic resonance (QMR) technology.<sup>21</sup> The cats were then allotted into two groups (CCR and ICR groups) using restricted randomization, balanced for MER, percentage of body fat, BCS, and body weight, with 14 cats per group (Table 2).

### Feeding Protocol and Key Measurements

The cats had free access to water at all times. The cats in the CCR group were fed 75% of their baseline MER for six months. The cats in the ICR group were fed 75% of their baseline MER during the first half of each month and then 100% of their baseline MER during the second half of the month for 12 months. Any cats that reached ideal BCS (5 of 9) were removed from the weight-loss study. The study was terminated when all the cats reached ideal BCS or at the end of six months for the CCR group and 12 months for the ICR group. The attending veterinarian, who was blinded regarding treatment group assignments, made the decision whether cats had reached ideal BCS. This was the end point of the study. In addition to baseline measurements, study measures included daily food intake, weekly body weight, biweekly BCS, bimonthly CBC, bimonthly blood serum chemistry panel, and monthly body composition measured by QMR.<sup>21</sup>

### Statistical Analysis

Restricted randomization was used to achieve balance in baseline MER, body weight, percentage body fat and BCS between groups. Linear mixed model (PROC MIXED) was used to evaluate the effects of treatment group, time and group by time interactions. The results were compared based on equal caloric restriction (one month of caloric restriction in the cats of CCR = two months of caloric restriction in the cats of ICR group), for example, the results of CCR at month one were compared with the results of ICR at month two, and CCR at month six with ICR at month 12. The month used in the results and discussion was the actual month of CCR. The

**Table 1.** Dietary Composition

Nutrient composition (dry matter)	
Crude protein.....	56.19
Crude fat.....	8.79
Carbohydrate.....	21.53
Crude fiber.....	5.77
Ash.....	7.44
Energy content	
ME(kcal/kg).....	3440.05

**Table 2.** MER (food intake), Body Weight, % Body Fat, and BCS at Baseline\*

	CCR		ICR	
	Mean	SEM	Mean	SEM
MER (food intake, g/day)	74.14	3.63	73.29	3.14
Body weight (kg)	6.00	0.13	5.80	0.18
% body fat (%)	33.88	1.82	32.89	1.34
BCS	7.50	0.17	7.43	0.14

CCR = continuous caloric restriction; ICR = intermittent caloric restriction  
\* n=14

rates of percentage of body-weight loss and percentage of body-fat loss were analyzed based on both monthly measurements and equal caloric restriction. Three cats in the ICR group became self-limiting and didn't eat all the foods during the study, and the food intake pattern of these three cats did not fit into ICR food intake pattern. We decided not to include the data of these three cats in statistical analyses. We also reanalyzed the baseline data without these cats, and there was no significant difference in any of the baseline parameters (data not shown).

## Results

### Effects of the CCR and ICR on Weight-Loss Progression Based on Equal Caloric Restriction

By the end of the study, 9 of 14 (64.29%) cats in the CCR group failed to reach ideal BCS, while only 2 of 11 (18.18%) cats in the ICR group failed to reach the ideal BCS (Table 3). Therefore, only 5 of 14 cats (35.71%) in the CCR group completed the weight-loss study successfully, while 9 of 11 cats (81.82%) in the ICR group were successful at the end of the weight-loss study.

CCR		ICR	
Month	Cats still on test (n)	Month	Cats still on test (n)
0	100% (14)	0	100% (11)
1	100% (14)	2	100% (11)
2	100% (14)	4	90.91% (10)
3	92.86% (13)	6	54.55% (6)
4	78.57% (11)	8	54.55% (6)
5	64.29% (9)	10	27.27% (3)
6	64.29% (9)	12	18.18% (2)

CCR = continuous caloric restriction; ICR = intermittent caloric restriction  
n= number of cats with BCS higher than 5 and remaining in the weight loss study

### Effects on Body Weight and Body Composition Based on Equal Caloric Restriction

Cats in both groups lost comparable amounts of body weight during the study (Table 4) and maintained lean-body mass equally well (Table 5). Cats in both groups had comparable amounts of body fat at baseline and during the first two months of weight loss. Body fat of the cats in the ICR group became significantly lower from month three to month six compared to that of cats in the CCR group (Table 6). Similarly, cats in both groups had comparable percentage of body fat at baseline and during the first three months of weight loss, and percentage of body fat of cats in the ICR group became significantly lower than those in the CCR group from month four to month six (Table 7).

### Effects on the Rates of Percentage of Body-Weight Loss and Percentage of Body-Fat Loss

When the rates of loss were calculated based on monthly measurements, there were no significant differences in the rates of percentage of body-weight loss or percentage of body-fat loss (Table 8), even though cats in the ICR group were fed 75% of their baseline MER only during the first half of the month. When the rates were calculated based on equal caloric restriction (one month in CCR = two months in ICR), the cats in the ICR group had a significantly higher rate of percentage of body-fat loss than the cats in the CCR group.

## Discussion

The objective of this study was to evaluate the effects the CCR and ICR on weight loss and body composition in overweight cats. When the results were compared based on equal caloric restriction, the cats in the ICR groups appeared to lose body fat and percentage of body fat easier than the cats in the CCR groups. By the end of the third month of weight loss, almost 46% of the cats in the ICR group reached BCS of 5, compared with only 7% cats in the CCR group. At the end of the study, only 18% cats in the ICR group failed to reach the ideal BCS of 5, while 64% of the cats in the CCR group failed

CCR			ICR			
Month	Mean (n)	SEM	Month	Mean (n)	SEM	p-value
0	6.01 (14)	0.18	0	5.95 (11)	0.20	0.8282
1	5.65 (14)	0.18	2	5.35 (11)	0.20	0.2872
2	5.37 (14)	0.18	4	5.16 (10)	0.20	0.4489
3	5.23 (13)	0.18	6	4.92 (6)	0.21	0.2682
4	5.09 (11)	0.18	8	4.76 (6)	0.21	0.2428
5	4.93 (9)	0.18	10	4.55 (3)	0.24	0.1940
6	4.81 (9)	0.19	12	4.45 (2)	0.24	0.2374

CCR = continuous caloric restriction; ICR = intermittent caloric restriction  
\* n=number of cats with BCS higher than 5 remaining in the weight-loss study

**Table 5. Effects of CCR and ICR on Lean Body Mass (kg)**

CCR			ICR			
Month	Mean (n)	SEM	Month	Mean (n)	SEM	p-value
0	3.32 (14)	0.13	0	3.44 (11)	0.14	0.5289
1	3.29 (14)	0.13	2	3.56 (11)	0.14	0.1671
2	3.46 (14)	0.13	4	3.55 (10)	0.14	0.6402
3	3.41 (13)	0.13	6	3.46 (6)	0.14	0.8103
4	3.41 (11)	0.13	8	3.52 (6)	0.14	0.5653
5	3.32 (9)	0.13	10	3.42 (3)	0.15	0.6130
6	3.28 (9)	0.13	12	3.45 (2)	0.16	0.4187

CCR = continuous caloric restriction; ICR = intermittent caloric restriction  
n= number of cats with BCS higher than 5 and remaining in the weight loss study

**Table 6. Effects of CCR and ICR on Body Fat (kg)**

CCR			ICR			
Month	Mean (n)	SEM	Month	Mean (n)	SEM	p-value
0	2.04 (14)	0.13	0	1.88 (11)	0.15	0.4051
1	1.79 (14)	0.13	2	1.42 (11)	0.15	0.0761
2	1.60 (14)	0.13	4	1.27 (10)	0.15	0.1100
3	1.49 (13)	0.13	6	1.07 (6)	0.15	0.0434
4	1.38 (11)	0.13	8	0.92 (6)	0.15	0.0294
5	1.27 (9)	0.13	10	0.74 (3)	0.16	0.0176
6	1.16 (9)	0.14	12	0.62 (2)	0.17	0.0179

CCR = continuous caloric restriction; ICR = intermittent caloric restriction  
n= number of cats with BCS higher than 5 and remaining in the weight loss study

**Table 7. Effects of CCR and ICR on % Body Fat (%)**

CCR			ICR			
Month	Mean (n)	SEM	Month	Mean (n)	SEM	p-value
0	33.82 (14)	2.26	0	31.82 (11)	2.54	0.5600
1	31.33 (14)	2.26	2	26.67 (11)	2.54	0.1815
2	29.41 (14)	2.26	4	24.70 (10)	2.55	0.1771
3	28.03 (13)	2.26	6	21.69 (6)	2.57	0.0742
4	26.60 (11)	2.26	8	19.09 (6)	2.60	0.0374
5	24.92 (9)	2.26	10	16.08 (3)	2.62	0.0162
6	23.28 (9)	2.27	12	14.27 (2)	2.66	0.0149

CCR = continuous caloric restriction; ICR = intermittent caloric restriction  
n= number of cats with BCS higher than 5 and remaining in the weight loss study

**Table 8. Effects of CCR and ICR on the Rates of Weight Loss and % Body Fat Loss**

CCR			ICR		
	Mean (n)	SEM	Mean (n)	SEM	p-value
The Loss Rate (% loss/month) based on monthly results					
% BW loss/m	3.88 (14)	0.47	2.73 (11)	0.36	0.2105
% BF loss/m	1.95 (14)	0.32	1.78 (11)	0.26	0.8923
The Loss Rate (% loss/month) based on equal caloric restriction					
% BW loss/m	3.88 (14)	0.47	5.46 (11)	0.73	0.0791
% BF loss/m	1.95 (14)	0.32	3.56 (11)	0.52	0.0457

CCR = continuous caloric restriction; ICR = intermittent caloric restriction  
BW = body weight; BF = body fat n= number of cats in the weight loss study



to reach BCS of 5. These data indicated that the ICR regimen was much better than the CCR regimen in promoting body-fat loss in overweight cats.

The cats were removed from the study whenever their BCS was reduced to 5, therefore, the amount of time each cat stayed in the weight-loss study varied. The rates of percentage of body-weight loss and body-fat loss were then calculated based on actual time on the study. When the results were calculated based on equal caloric restriction, the cats in the ICR group had a significantly higher rate of percentage of body-fat loss than the cats in the CCR group. The rate of percentage of body-weight loss was marginally significant ( $p=0.0791$ ) between the two groups with the cats in the ICR group having a higher rate. But when the results were calculated based on monthly measurements, the rates of both percentage of body-weight loss and percentage of body-fat loss were not significantly different between the two weight-loss regimens. This is very interesting because within each month, the cats in the ICR group were fed 75% of their baseline MER only during the first half of the month, while the cats in the CCR group were fed 75% of their baseline MER during the whole month. Since the cats in both groups ate the same diet, comparable monthly weight loss and body-fat loss suggest that the cats in the ICR may maintain higher energy expenditure during the whole weight-loss study. This is in contrast to previous research that showed cats fed traditional CCR to induce weight loss lowered their energy expenditure resulting in stalled progression of their body-weight loss.<sup>7</sup>

When the results were compared based on equal caloric restriction, cats in both groups lost comparable amounts of body weight. This observation is consistent with the human study that showed that 5+2 ICR was as effective as CCR with same caloric restriction in promoting weight loss in overweight and obese subjects.<sup>20</sup> Some loss of lean-body mass has been shown to be expected in cats during weight loss.<sup>5</sup> Surprisingly, the high-protein weight-loss diet used in this weight-loss study completely prevented loss of lean-body mass of the cats in both CCR and ICR groups.

The results from body composition changes showed that the cats in both groups lost similar amounts of body fat during the first two months of the weight-loss study, and then cats in the ICR group lost significantly more body fat than cats in the CCR group from the third month to the end of the study. Similar results were observed in the changes of percentage of body fat. These data indicated that the cats in the CCR group responded to reduced caloric intake by mobilizing body fat initially and then started to lower their daily energy expenditure to slow down the loss of body fat. This is consistent with the adverse consequence of CCR.<sup>7</sup>

In summary, the ICR regimen was more effective than the CCR regimen in promoting body-fat loss and may be able to sustain higher energy expenditure in the cats during the weight loss.

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