Increased Dietary Protein Promotes Fat Loss and Reduces Loss of Lean Body Mass During Weight Loss in Cats

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ABSTRACT

An important goal in the management of obesity is to reduce excess body fat while minimizing the loss of lean tissue. This study evaluated whether increasing dietary protein would increase fat loss and minimize loss of lean body mass in cats during weight loss. Isocaloric diets containing approximately 35% or 45% of energy from protein were fed to achieve weight loss of 1% of body weight per week. The high-protein diet resulted in a greater loss of body fat and greater retention of lean body mass compared with the control diet.

INTRODUCTION

Overweight and obese cats make up at least 25% of feline patients seen by veterinary practices in the United States.[1,2] Obesity in cats is linked to numerous health problems, including an increased risk for diabetes mellitus, lameness, and nonallergic skin conditions. It is projected that weight loss until optimal body condition could eliminate from 12% to 22% of feline lameness and diabetes mellitus.[1]

Traditional weight-management diets have focused on reducing calories through low fat content and increased dietary fiber. Replacing dietary fat with complex carbohydrates not only reduces the gross energy content, it leverages metabolic differences between these nutrients. Metabolic energy expenditure is 9% to 12% greater with high-carbohydrate diets versus high-fat diets.[3] Fat is used more efficiently for both oxidation to adenosine triphosphate (ATP) and for fat deposition in adipose tissue.[3,4] Dietary fiber provides a satiety effect and stimulates postprandial thermogenesis.[5–7] Low-fat, high-fiber foods generally have a lower calorie density that allow cats to consume more food while still reducing calories. Such diets have proven effective for feline weight management.[8] In recent years, however, the role of protein in weight management has come to the forefront.

Dietary protein has several effects that may be beneficial during weight loss. Protein stimulates increased postprandial thermogenesis and increased protein turnover.[9–13] The heat increment in the postprandial period associated with high protein intake is approximately 68% greater than that from isocaloric carbohydrate intake, which appears to be due to increased protein turnover. Increased protein synthesis accounts for approximately 20% of energy expenditure following a high-

protein meal, compared to 12% following an isocaloric high-carbohydrate meal.[11] These energy-consuming metabolic effects result in less net energy being available from protein. Accordingly, the relative ATP yields from the oxidation of fat, carbohydrate, and protein approximate 90%, 75%, and 55%, respectively.[3] Thus, replacing dietary fat or carbohydrate with protein results in less net energy available from the diet.

Perhaps due to its thermogenic effect, protein also provides a superior satiety effect compared with fats or carbohydrates.[14,15] Several investigators have noted that higher protein, weight-loss diets result in greater satiety during clinical weight loss programs compared with higher carbohydrate diets.[16–18]

Increased dietary protein also appears to aid in achieving an important goal of weight management, which is to lose body fat while conserving lean body mass (LBM). Maintaining metabolically active LBM is important for maintaining resting and total energy expenditure to prevent rapidly regaining weight.[19] Reduction of nonprotein energy intake, such as during calorie restriction for weight loss, increases the relative protein requirements to maintain the body's protein content.[20] Several controlled trials in humans and dogs have shown that an increased proportion of protein in low-calorie diets resulted in increased loss of body fat or reduced loss of LBM.[17,21–23] To date, similar research in cats has not been published. Thus, the objective of this study was to determine if increasing dietary protein in a low-calorie diet would increase fat loss and minimize loss of LBM in cats.

Table 1. Key Ingredients and Nutrient Analyses of Experimental Diets

	Normal Protein Diet (CP)	High-Protein Diet (HP)
Ingredients	**Percentage of Ingredient in Diet (%)**	
Corn	23.5	1.8
Corn gluten meal	21.3	31.1
Soybean meal	5.0	8.0
Poultry meal	10.0	16.0
Soybean hulls	22.0	25.0
Pea fiber	10.0	10.0
Beef fat	2.5	2.5
Vitamins, minerals, and flavoring	5.7	5.6
Nutrients	**Percentage of Nutrient in Diet (as fed) (%)**	
Moisture	4.9	8.3
Protein	30.0	39.1
Fat	9.0	8.9
Crude fiber	14.0	14.5
Metabolizable energy (kJ/g)	12.0	12.3
Protein (percentage of metabolizable energy)*	36.5	46.4

*Assumes an energy value for protein of 14.6 kJ/g.

MATERIALS AND METHODS

Animals

Two groups of 8 healthy, overweight, adult female cats were established that were equivalent in mean body weight and body condition score (BCS),[24] as well as age and neuter status. Cats were individually housed and maintained in environmentally controlled rooms. Food was provided for approximately 16 hours daily, and water was available ad libitum.

Diets

One group was randomly assigned to receive a high-protein diet (HP) and the control group received a normal protein (CP) diet. Both diets were extruded, dry diets with a moisture content less than 10%. Diets were formulated to be as similar as possible, with protein-containing ingredients in the HP diet substituted for ground yellow corn in the CP diet. Diets were formulated to contain 30% (CP) or 40% (HP) dietary crude protein, on an as-fed basis. Key ingredients and nutrient analyses are shown in Table 1.

Experimental Procedures

Cats were adapted to their environment and diets over a 2-week baseline period. At the end of this period and following an overnight fast, blood was sampled for biochemical analysis, and body composition of each cat was analyzed by dual energy x-ray absorptiometry (DEXA) (Lunar Corporation, Madison, WI). Subsequently, cats were fed their respective diets in restricted amounts to facilitate a targeted rate of weight loss of 1% of body weight per week.

Calorie allowances for each cat were generated by a computer program (PVD OM-Weight Management Software, Nestlé Purina PetCare, St. Louis, MO).[25] The program's calculations assume that changes in adult body weight are due to changes in adipose and supporting tissue, which contain approximately 85% fat and 33.14 kJ/g. Initial feeding allowances were based on estimated maintenance energy requirements (293 kJ/kg) for actual body weight less the calorie deficit needed to achieve a 1% rate of weight loss.

Cats were weighed and BCS was assessed using a 9-point system[24] every 4 weeks. Each cat's food allowance was individually adjusted according to the computer program. Calorie allowances determined at all monthly rechecks used actual energy requirements determined by the computer, based on known intake and changes in body weight over the prior 4 weeks, less the appropriate calorie deficit for targeted weight loss. Food intake was recorded daily for each cat throughout the study.

Up to 6 months were allowed for weight loss. However, cats that achieved their ideal body weight (estimated during the baseline period) prior to that time were deemed to have completed the study and were fed to maintain weight. At 6 months or upon achieving ideal body weight, serum biochemistry and body composition analyses by DEXA were repeated.

Statistical Analysis

Data were analyzed using a Student *t*-test. For non-normally distributed data, such as composition of lost weight, a Mann-Whitney rank sum test for non-parametric data was used. Differences were considered significant if $P < 0.05$; however, probability values between $P = 0.05$ and $P = 0.10$ are

Table 2. Key Serum Biochemical Values from Cats Undergoing Weight Loss Fed Different Diets

		Normal Protein Diet (CP)		High-protein Diet (HP)		
	Units	Mean	SD*	Mean	SD*	Probability
Glucose, initial	mmol/L	5.09	0.36	5.05	0.90	NS
Glucose, final	mmol/L	5.41	2.11	4.86	0.43	NS
Urea nitrogen, initial	mmol/L	7.27	1.27	6.80	1.38	NS
Urea nitrogen, final	mmol/L	7.96	1.62	7.84	1.80	NS
Creatinine, initial	mmol/L	0.12	0.01	0.12	0.02	NS
Creatinine, final	mmol/L	0.10	0.01	0.09	0.00	$P = 0.056$
Alanine transaminase, initial	U/L	41.75	7.03	51.14	16.67	NS
Alanine transaminase, final	U/L	35.00	9.62	50.43	24.42	NS
Alkaline phosphatase, initial	U/L	45.63	17.12	50.86	18.96	NS
Alkaline phosphatase, final	U/L	32.63	9.83	35.86	6.12	NS
Total protein, initial	g/L	70.25	3.92	69.86	2.73	NS
Total protein, final	g/L	65.50	5.10	66.70	6.32	NS
Albumin, initial	g/L	34.63	3.85	36.14	2.27	NS
Albumin, final	g/L	30.63	2.13	32.70	1.25	$P = 0.043$
Cholesterol, initial	mmol/L	2.19	0.49	2.57	0.28	$P = 0.089$
Cholesterol, final	mmol/L	2.56	0.46	2.98	0.24	$P = 0.046$
Triglycerides, initial	mmol/L	3.12	1.22	4.23	1.05	$P = 0.085$
Triglycerides, final	mmol/L	1.58	0.93	2.23	0.78	NS

*SD indicates standard deviation; NS, not significant, $P > 0.10$.

presented. Data are presented as means ± standard deviations unless otherwise noted.

RESULTS

One cat was removed from the HP group for lack of food intake during the first 2 weeks of the study. The remaining cats completed the study in good health. Serum biochemistry remained within normal limits during the study, although a few values differed by diet (Table 2). The initial body weight, BCS, and percentage of body fat averaged 5.39 kg, 7.9, and 47.7%, respectively, for both groups.

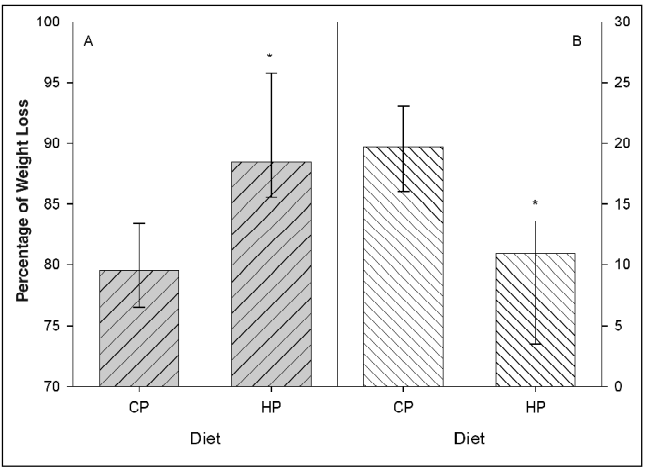

Figure 1. Effect of diet on composition of weight loss during controlled weight loss in cats. Diets provided normal protein (CP) or high protein (HP) content, as described in the text. Shown are median loss of fat (A) and median loss of lean tissue (B). Error bars reflect the 25th and 75th percentiles. For both loss of lean and loss of fat, the effect of diet was significant ($P = 0.014$).

Despite feeding each cat based on individual calorie allowances, mean calorie intake during weight loss did not differ between groups, averaging 709 ± 135 kJ/d and 739 ± 131 kJ/d for the CP and HP diets, respectively. Likewise, neither rate of weight loss nor total weight loss differed between diets (Table 3).

Body weights determined on the same day by standard scale and by DEXA differed by 3.9% or less, confirming appropriate selection of DEXA software for all cats. Overall, percentage of body fat decreased by 28%, from 47.7% to 34.3%; however, percentage of fat loss was significantly greater in HP cats (Table 4). Change in bone mineral content contributed only 0.51 ± 0.19% to 0.66 ± 0.20% for the CP and HP groups, respectively, and did not differ by diet. Absolute loss of lean tissue was reduced by approximately 50% in HP cats (Table 4). A significantly ($P = 0.014$) greater proportion of weight loss was fat in cats fed the HP diet (Figure 1). Likewise, HP cats lost a smaller proportion of lean body mass ($P = 0.014$).

DISCUSSION

An important goal for obesity management is to lose fat while retaining lean body mass. Fat loss, as opposed to weight loss, is associated with decreased mortality in humans.[26] Lean body mass retention is important for maintaining resting energy requirements, which may lessen the risk for weight rebound.[19] In cats, total energy expenditure is directly related to lean body mass.[27] Furthermore, lean body mass serves an important role as a protein reservoir to support protein turnover.[28] Protein turnover not only contributes to energy expenditure, but supports synthesis of life-critical proteins, including immunoproteins.[29,30]

In this study, cats fed the higher-protein diet lost more body fat while reducing their loss of lean body mass by 50%. These findings are consistent with those reported in other species undergoing weight loss.[17,22,23,31] Likewise, the composition of weight loss in cats fed the HP diet in this study was similar to that reported for another group of cats fed a similar protein level for weight loss.[32]

Composition of weight loss can be influenced by rate of weight loss as well as nutrient composition of the diet.[33] In this study, average energy intake, total weight loss, and rate of weight loss were constant between

Table 3. Change in Body Weight and Body Condition Score (BCS) During Weight Loss in Cats Fed Different Diets*

	Normal Protein Diet (CP)	High-Protein Diet (HP)
Initial BCS	7.9 + 1.1	7.9 + 0.7
End BCS	5.8 + 1.3	5.9 +1.0
Initial body weight (kg)	5.4 ± 0.8	5.4 ± 0.7
End body weight (kg)	4.3 ± 0.6	4.3 ± 0.5
Total loss, percentage of initial weight	16.2 + 6.2	17.5 + 4.9
Rate of loss, percent/week (mean + SD†)	1.1 ± 0.4	1.0 ± 0.2
Rate of loss, percent/week (minimum – maximum)	0.78 – 1.9	0.74 – 1.3

*Differences were not significant, $P > 0.10$.
†SD indicates standard deviation.

Table 4. Change in Body Composition as Determined by Dual Energy X-ray Absorptiometry (DEXA) in Cats Fed Different Diets

	Normal Protein Diet (CP)	High-Protein Diet (HP)	Probability
Initial percent of fat	47.6 ± 1.7	47.8 ±1.4	NS*
End percent of fat	35.9 ± 2.6	32.5 ± 2.1	NS
Change in percent of fat	–11.8 ± 1.2	–15.4 ± 0.9	$P < 0.001$
Initial grams of fat	2847 ± 243	2849 ± 235	NS
End grams of fat	1601 ± 190	1427 ± 154	NS
Change in grams of fat	–1246 ± 95	–1422 ± 89	$P < 0.001$
Initial grams of LBM	3062 ± 64	3055 ± 82	NS
End grams of LBM	2769 ± 57	2908 ± 88	NS
Change in grams LBM	–292 ± 59	–148 ± 53	$P < 0.001$

*NS indicates not significant, P > 0.10; LBM, lean body mass.

treatment groups to achieve a targeted rate of loss of 1% initial body weight per week. More rapid weight loss may be associated with an increased loss of lean body mass. Cats lost twice as much lean body mass (8% vs 19%) when the rate of weight loss was increased from approximately 1% to 1.3% of body weight per week.[33] On the other hand, clients may become discouraged if weight loss is so slow as not to be noticeable. Therefore, weight loss and protection of lean body mass may best be achieved in cats losing weight at a rate of approximately 1% of body weight per week.

A typical 4-kg cat has a maintenance energy requirement of approximately 1,000 kJ/day. In this study, a 1% average rate of weight loss was achieved with energy restriction of approximately 35%. However, as individual cats vary greatly in energy requirements, the energy needed for weight loss varies. Appropriate monitoring and adjustments in calorie allowance may be needed to achieve the desired rate of weight loss.

A loss of lean body mass may occur when protein intake falls below minimum requirements since lean body mass serves as a protein reservoir to support necessary endogenous protein synthesis. The lower-protein diet (CP) used in this study was formulated to maintain minimum recommended levels of protein intake despite energy restriction. On average, cats fed this diet consumed approximately 3.5 g protein/kg body weight, which is within the recommended range for adult cats.[34,35] However, to

maintain nitrogen balance during periods of energy restriction, protein intake may need to be greater than normal maintenance levels.[3] Under normal conditions, non-protein energy needs are met by dietary fats and carbohydrates, which helps spare protein. During energy restriction, all macronutrients are readily oxidized for energy, diverting protein and amino acids that may be needed for protein synthesis. Cats fed the HP diet consumed an average of 4.8 g protein/kg body weight, while maintaining the same energy intake and rate of weight loss. With this higher intake of protein, lean body mass was spared, supporting the concept of increased protein requirements during periods of calorie restriction.

One concern veterinarians may have regarding managing obese cats is the risk for idiopathic hepatic lipidosis (IHL). Obese cats undergoing a severe restriction in energy intake or extensive weight loss are at increased risk for developing IHL.[36,37] In cats, this condition can be fatal if not treated aggressively. Markers of IHL include elevated liver enzymes. In this study, all cats remained healthy and liver enzymes actually decreased by the end of the trial. In experiments to induce IHL, providing 25% of daily energy requirements as protein reduced hepatic lipid accumulation and other evidence of IHL, compared with providing fat or carbohydrates.[36] Thus, protein helps to protect against IHL, and feeding a diet with an increased percentage of calories from protein to achieve a rate of weight loss of approximately 1% of body weight per week supports safe weight loss.

In conclusion, this study confirmed that feeding a low-fat, moderate-fiber diet with 45% of energy from protein helps cats lose body fat while conserving lean body mass. Energy restriction to achieve a weekly rate of loss equivalent to 1% of body weight is appropriate for safe weight loss while optimizing loss of fat and minimizing loss of lean body mass. Preservation of lean body mass may aid in long-term weight management.

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