Weight Loss Does Not Influence Energy Expenditure or Leucine Metabolism in Obese Cats1,2

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EXPANDED ABSTRACT

KEY WORDS: • obesity • body composition • energy expenditure • protein turnover • cats

Excess body weight and obesity, two common problems in household cats, seem to have become even more frequent in last decades (1). Because feline obesity increases the risk of diabetes mellitus, nonparasitic skin diseases, lameness, and hepatic lipidosis as well as reduces life expectancy (1,2), prevention and treatment are of the utmost importance to the well-being and health of these animals.

Weight reduction is usually obtained by restricting energy intake. Cats, as true carnivores, are unable to adapt their metabolism to low nitrogen intake (3). Hepatic lipidosis, another concern of weight loss programs, can be avoided by reducing energy intake moderately and maintaining high protein intake (4).

In humans (5), mice (6) and dogs (7), weight-loss programs have resulted in lower energy expenditure related to a decrease in metabolic rate, lean body mass and physical activity. In humans, lean tissue loss is greater than severe than after moderate energy restriction (8). Higher protein intake can help prevent or at least minimize lean body mass loss in obese humans (9) as well as in obese dogs (10).

The purpose of this study was to assess the influence of weight loss on body composition, energy expenditure and protein turnover and then compare the effects on these parameters of two diets differing mainly in protein content.

Animals, experimental diets and feeding protocol

Seven neutered, domestic short-haired cats (1 female, 6 males) were used in a 21-wk study. The animals were group-housed in pens and maintained on a 12-h light/dark cycle at 20–24°C. Experimental protocols adhered to European Union guidelines and were approved by the Animal Use and Care Advisory Committee of Nantes.

The mean age at the beginning of the study was 6.2 ± 0.7 y (3.2–8.6 y) (Table 1), and all animals had been obese for at least 1 y. The degree of obesity was assessed by body condition scoring (BCS)1 on a 1-to-5 scale (11). Except for obesity, all animals were healthy according to clinical examination, serum chemistry, urinalysis and hormonal profiles. Target (final) body weights (BW) were estimated on the basis of values for cats in optimal condition (BCS = 3) and of the same body size and shape. Mean estimated excess BW at the beginning of the study was 35 ± 2% (27–44%).

Before the study, cats were group-housed and had free individual access through electromagnetic doors to a baseline commercial dry cat food [crude protein (CP) 33%, ether extract 20%, crude fiber 2%, 19.0 MJ ME/kg, as feed]. During this 6-wk baseline period, individual intakes were recorded daily.

Animals were then allotted into two groups (A and B) and fed either an experimental high-protein diet5 (diet A, four cats) or a commercial obesity diet6 (diet B [Hill's Feline r/d, Topeka, KS], three cats) (see Table 1).

Initially, each group A cat received the same daily amount as the

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4 Abbreviations used: BCS, body condition score; BF%, body fat content; BW, body weight; CP, crude protein; FFM, free-fat mass; ME, metabolizable energy; NOLD, nonoxidative leucine disposal; OXLeu, leucine oxidation rate; RALeu, leucine appearance rate; REE, resting energy expenditure.

5 Diet A contained poultry by-product meal, corn gluten meal, cellulose, rice gluten meal, beet pulp, barley, poultry oil, poultry liver digest, psyllium, brewer’s yeast, fructo-oligosaccharides, L-carnitine, minerals and vitamins.

6 Diet B contained poultry by-product meal, ground corn, powdered cellulose, corn gluten meal, chicken liver digest, vegetable oil, meat protein isolate, glyceryl monostearate, taurine, L-carnitine, minerals, vitamins, BHT, BHA and ethoxyquin.
# TABLE 1

Initial and final body weight (BW), body condition score (BCS), body fat content, time to reach final BW, and mean weekly BW loss in obese cats fed either a high-protein (A) or a medium-protein diet (B) to restore optimal BW (mean ± SEM)

<table>
<thead>
<tr>
<th></th>
<th>Overall (n = 7)</th>
<th>Diet A1 (n = 4)</th>
<th>Diet B2 (n = 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>6.2 ± 0.7</td>
<td>6.3 ± 0.3</td>
<td>6.0 ± 0.9</td>
</tr>
<tr>
<td>Initial BW (kg)</td>
<td>6.5 ± 0.3</td>
<td>6.3 ± 0.4</td>
<td>6.8 ± 0.6</td>
</tr>
<tr>
<td>Initial BCS</td>
<td>4.4 ± 0.2</td>
<td>4.1 ± 0.3</td>
<td>4.7 ± 0.3</td>
</tr>
<tr>
<td>Final BW (kg)</td>
<td>4.8 ± 0.2</td>
<td>4.5 ± 0.2</td>
<td>5.2 ± 0.3</td>
</tr>
<tr>
<td>Final BW final BW (%)</td>
<td>135 ± 2</td>
<td>139 ± 2</td>
<td>131 ± 2</td>
</tr>
<tr>
<td>Time to final BW (d)</td>
<td>133 ± 8</td>
<td>142 ± 10</td>
<td>121 ± 13</td>
</tr>
<tr>
<td>Mean weekly BW loss (%)</td>
<td>1.60 ± 0.07</td>
<td>1.61 ± 0.08</td>
<td>1.58 ± 0.15</td>
</tr>
<tr>
<td>Initial body fat content (%)</td>
<td>44 ± 2</td>
<td>46 ± 2</td>
<td>41 ± 1</td>
</tr>
<tr>
<td>Final body fat content (%)</td>
<td>28 ± 3</td>
<td>30 ± 4</td>
<td>26 ± 7</td>
</tr>
</tbody>
</table>

1 Diet A: CP 45.2%, ether extract 6.8%, total dietary fiber 18.3%, 13.1 MJ ME/kg.
2 Diet B: CP 34.0%, ether extract 6.8% total dietary fiber 24.6%, 11.2 MJ ME/kg.
3 Significantly different from Diet A, P < 0.05.

## Measurements

### Biometrics and clinical evaluation.

BW and BCS were recorded weekly. The average weekly BW loss rate (r, in %/wk) was calculated as follows:

\[
\text{Target BW} = \text{Initial BW} \times (100 - r)^{[\text{wk nb}]}
\]

where [wk nb] is the number of weeks needed to reach target BW.

### Body composition.

Total body water was measured by isotopic dilution of \(^2\)H\(_2\)O. On the day of the study, 12-h food-deprived cats were placed in individual cages for water restriction and body water equilibration from 2 h before to 3 h after tracer injection. Cats were injected subcutaneously (1.5 g/kg BW) with physiological saline \(^3\)H\(_2\)O (99.9%, \(^2\)H\(_2\)H; Leman, Saint-Quentin-en-Yvelines, France). Blood samples were collected from the jugular vein (5 mL) before and after 3 h after tracer injection. Deuterium was assayed by Fourier-transform infrared spectroscopy (13).

Total body water and fat-free mass (FFM in kg) were calculated as previously described (14). FFWM was corrected to take into account the lowering effect of proton exchange between water and organic compounds in the deuterium oxide dilution pool (13). Body fat content was calculated from BW and FFWM.

### Energy expenditure.

Resting energy expenditure (REE) was assessed four times (before and after weight loss and at two intermediate points) from continuous measurement of CO\(_2\) production and O\(_2\) consumption, as previously described (15). Daily REE [in kJ/(kg BW-d)] or in kJ/(kg FFM\(^{0.89}\)d) was extrapolated from 2- to 4-h measurements (15).

### Leucine fluxes.

As previously described (16), the \(^1\)C-leucine kinetic method was used to assess protein fluxes in overnight food-deprived animals, before and at the end of the weight-loss period.

Briefly, cats underwent a 3-h infusion of NaH\(^{13}\)CO\(_3\) [3 μmol/(kg·h)] after a priming dose of 6 μmol/kg to assess CO\(_2\) production, followed immediately by a 3-h intravenous infusion of L-[\(^1\)\(^3\)C]leucine [10 μmol/(kg·h)] after a priming dose of 15 μmol/kg to assess leucine appearance rate (Ra\(_{\text{Leu}}\)), oxidation (Ox\(_{\text{Leu}}\)) and nonoxidative leucine disposal (NOLD), expressed as μmol/(kg·h).

### Statistical analysis

Data were analyzed by repeated-measures ANOVA, using either one factor (diet) or two factors (time and diet). All statistical calculations were performed with Superanova software (Abacus Concepts, Berkeley, CA). A value of P ≤ 0.05 was considered as significant. Results are expressed as the means ± SEM.

## RESULTS

### Weight loss and food consumption

Body weight and BCS (Table 1) decreased significantly during the weight-loss period (P < 0.001) without a diet effect, as did fat mass and FFM (P < 0.001). Cats remained clinically healthy, and biochemical and hormonal analyses were not suggestive of metabolic disorders.

As indicated above, food allowance was adjusted to obtain a BW loss rate of 1–2% per wk. Overall mean energy consumption during the weight-loss period was 169 ± 9 kJ ME/(kg target BW-d) (157 ± 13 and 185 ± 5 in groups A and B, respectively, NS), that is, 66 ± 4% (62 ± 5 and 74 ± 2%, NS) of the assumed energy requirement for adult cats in optimal body condition [(250 kJ ME/(kg BW-d)] (17).

### Changes in energy expenditure

Mean extrapolated daily REE (n = 7) was 124 ± 4 kJ/(kg BW-d) and 218 ± 5 kJ/(kg FFM\(^{0.89}\)d). Differences between groups were not significant. REE expressed by kg BW increased as BW and body fat content decreased (P < 0.001), which explains why no significant change in REE was observed over the study when expressed on a FFWM basis.

### Leucine kinetics

A steady state was observed over the last 60 min of each isotope infusion in \(^1\)C-enrichments of plasma KIC and breath CO\(_2\). Leucine kinetic variables Ra\(_{\text{Leu}}\), Ox\(_{\text{Leu}}\) and NOLD did not change significantly during the experimental period and showed no diet effect. However, Ox\(_{\text{Leu}}\) tended to increase at the end of the weight-loss period (P < 0.08) and to be higher in group B (P < 0.09).

## DISCUSSION

Large differences for weight loss rates have been reported during obesity treatment in cats. Animals fed approximately 60% of their energy requirement [250 kJ ME/(kg target BW-d)] lost between 0.8% (18) and 1.6% (19) of their initial BW per 60% of their energy requirement [250 kJ ME/(kg BW-d)]. This was extrapolated from 2- to 4-h measurements (15).

High-protein diets have been shown to minimize lean body mass loss in humans (9) and dogs (22). In our study, small sample size and the modest difference in protein content...
between diets (30.4 and 34.5 g CP/[MJ ME]) may explain that no significant difference was observed between groups. In a previous study, an 18.1% BW loss (8.2% FFM and 90.5% fat) was obtained in 18 wk using a diet containing 29.2 g CP/[MJ ME] (18) (i.e., a mean weekly BW loss of 1.1%). In our study, cats fed a slightly higher level of protein lost 26% of initial BW in 19 wk (24% FFM and 76% fat) (i.e., a mean weekly loss of 1.6%). This supports in cats the concept developed in humans (8), that loss of lean tissue becomes greater as weight loss rate increases.

In other species, the decrease in energy expenditure correlates positively with the degree of energy restriction. This can be attributed to a decrease in metabolic rate, a loss of lean body mass (which has a much higher metabolic rate than adipose tissue), and a decrease in physical activity. Diet may also affect adaptation to energy restriction. High-protein, low-glycemic-index diets enhanced fat tissue oxidation and the conservation of muscle mass (27). Maintaining high protein intake, as in our study, reduces the decrease in energy expenditure during energy restriction (28).

The cats used in this study had been obese for more than 1 yr. Their metabolic rate was probably already low, and living in a cattery could have made them lazy. Thus, energy restriction would not have induced a significant decrease in activity level. The relatively high protein level of the diets could also have contributed to maintaining energy expenditure, given that wasting is high when protein is used as a source of energy. Because leucine kinetic variables at steady state can be converted to protein fluxes on the basis of commonly accepted assumptions (29), the 13C-leucine method was used in our study to assess the effects of weight loss on postabsorptive protein metabolism. To our knowledge this method has not been used previously in cats. Our results are consistent with those previously reported for other species, especially dogs (30).

No significant differences in leucine appearance rate (RaLeu) and utilization for protein synthesis (NOLD) were observed before and after weight loss or between diets, which is consistent with previous human (31,32) and dog studies (30). Only a nonsignificant increase in leucine oxidation rate (OxLeu) was observed at the end of the weight-loss period. In a recent study, weight loss induced no significant changes in leucine kinetic variables in obese women (31). In some human studies, high protein intakes were associated with a decrease in postabsorptive leucine oxidation rate compared to intake close to the requirement (33). In our study, both weight loss and protein intake factors were involved. Because group size was limited in this first application of the 13C-leucine method to cats, our results do not allow definitive conclusions. However, this method would seem useful to assess protein metabolism in various situations in cats.

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LITERATURE CITED