Rapid Weight Loss with a High-Protein Low-Energy Diet Allows the Recovery of Ideal Body Composition and Insulin Sensitivity in Obese Dogs1,2

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EXPANDED ABSTRACT

Obesity and overweight are very common in dogs of all Western countries (1), increasing the risk of several different diseases such as cancers (2,3), osteoarticular disorders, or diabetes (4). Some studies of obesity in dogs also showed that insulin resistance (IR) is a prominent feature (5,6) that could lead to complications such as diabetes (4). Some studies of obesity in dogs also showed that obesity induces such modifications of TNFα which could also be involved in IR.

The aim of this study was to test the ability of a low-energy and high protein:energy–ratio diet to enable a rapid weight loss while preserving the lean body mass in dogs and to evaluate the influence of the obesity treatment on insulin sensitivity and two insulin resistance–related factors, TNFα and IGF-1.

MATERIALS AND METHODS

Six adult obese male Beagle dogs aged 4–9 y old (5.5 ± 2.1 y), whose ideal body weight (iBW) and body composition had been previously determined were used. The dogs had developed a nutritional obesity one year previously as described elsewhere (10). Briefly, the dogs were fed ad libitum a high-energy diet (75% of the energy allowance from a dry diet, 4790 kcal metabolizable energy/kg (ME/kg) on dry matter basis, crude protein (CP) 71 g/Mcal ME, and 25% from a canned food, 3860 kcal ME/kg on dry matter basis, CP 91 g/Mcal ME). They were then given a commercial high-energy nutritionally balanced food (as fed 4420 kcal ME/kg; CP 71 g/Mcal ME) to maintain their high body weight. A study, dogs whose BW exceeded iBW by at least 25% (141 ± 9%; 126–179%), were fed once daily a commercial diet, nutritionally balanced, and designed to treat obesity (in vivo 2520 kcal ME/kg as fed; 103 g CP/Mcal ME, thus approximately twice the minimum NRC 2004 minimum recommendation (11); l-carnitine 300 mg/kg).

The energy allowance (75 kcal ME/iBW0.67) corresponded to 50% of the maintenance energy requirements (MER) (12) using the dogs’ target body weight (13); this design was chosen to induce a rapid weight loss (2–3%/wk) and to cover the minimal requirement in proteins as the protein:energy ratio of the diet was twice the minimum.

Body composition [fat (FM) and fat-free mass (FFM)] was determined, at ideal body weight (T1), during the obese state (T2), and after weight loss (T3), using dilution of a single dose of deuterium oxide (0.5 g/kg) (14).

The euglycemic hyperinsulinemic clamp technique (10) was performed at T1, T2, and T3 to assess the insulin sensitivity, for which changes were expressed as the relative change in the glucose infusion rates required to maintain euglycemia at either T2 or T3 compared to the glucose infusion rate at T1.

Plasma TNFα was measured using an enzymatic immunoassay, and plasma IGF-1 was performed with a commercial immunoradiometric assay as previously described (15). Both TNFα and IGF-1 were measured at T1, T2, and at wk 6, 9, 12, 15, 18, 21, and 23 during the weight-loss period.

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4 Abbreviations used: BW, body weight; CF, crude fiber; CP, crude protein; DM, dry matter; EE, ether extract; FFM, fat-free mass; FM, fat mass; GIR, glucose infusion rate; iBW, ideal body weight; IGF-1, insulin-like growth factor 1; IR, insulin resistance; ME, metabolizable energy; TNFα, tumor necrosis factor alpha.

5 Virbac Vet Complex Chien Adult Hypocalorique® Laboratoire VIRBAC France SA, BP 447, F-06 515, Carros, France. Composition as fed: crude protein 26%; ether extract 8%; ash 7%; crude fiber 14%; DM 92%; calcium 1.2%; phosphorus 0.9%; vitamin A 14,500 IU/kg; vitamin D-3 1450 IU/kg; vitamin E 145 mg/kg; copper 26 mg/kg (as copper sulfate); l-carnitine 300 mg/kg; 2520 kcal ME/kg (in vivo); 103 g CP/Mcal ME. Ingredients: bean pods, dehydrated animal proteins, cooked maize, deoiled soya, wheat bran, animal fats, beef pulp, linseed, maize gluten, vegetable fibers, sea salt, fructo-oligosaccharides, vitamins, minerals and trace elements, l-carnitine, chondroitin sulfate. NRC, National Research Council.
Results

After weight loss, the body weight of the dogs was similar to their ideal weight (Fig. 1). The duration of the weight-loss period was 42–161 d, with a mean of 85 ± 17 d, and a rate of 2.6 ± 0.4% of wt/wk.

The body fat-free mass after weight loss was similar to that assessed at ideal body weight (Fig. 2).

Insulin sensitivity was lower (P < 0.05) in obese dogs than in either of the other states, and did not significantly differ after weight loss from its initial value at ideal body weight (Table 1).

TNFα and IGF-1 were higher in obese dogs than in either of the other states (Figs. 3 and 4). Plasma IGF-1 concentration was different across time (ANOVA, P = 0.0003). Plasma TNFα concentration was not, due to a high standard deviation (ANOVA, P = 0.19), but was significantly different among the three states: ideal, obese, and after weight loss (Wilcoxon paired test, P < 0.05).

Discussion

The results of this study showed that a restricted energy supply with a low-energy and high protein:energy–ratio diet allowed a very satisfactory weight loss in obese dogs, quantitatively and qualitatively, because dogs returned to their basal weight and fat-free mass. The higher fat-free mass absolute value in the obese state may have been related to higher body fluids in obese dogs. However, in the obese state the fat mass increased much more, and the percent of the fat-free mass diminished significantly, representing ~67% vs. 83% in the dogs with ideal body weight.

Human studies found that a high-protein diet did preserve lean tissue mass (16) and promoted the loss of fat tissue (17). A high-protein, energy-restricted diet was also successful in reducing the body weight and body fat of overweight dogs (18) and cats (19), and in conserving lean body mass of dogs (20). The conservation of fat-free mass during weight loss may also have been helped by the high L-carnitine content of the diet (300 mg/kg) as described previously in obese dogs, fed a diet of similar L-carnitine content (21).

TNFα and IGF-1 are considered to be blood markers of insulin resistance (9,22) because it was shown that their overproduction is linked to the pathogenesis of this syndrome. Indeed, TNFα is known to impair insulin receptor signaling (23). Hotamisligil et al. (9) provided evidence that TNFα levels increase in obese and IR rodents. Several studies (24,25) reported an increase in plasma TNFα level in obese insulin-resistant subjects. Many studies in the literature showed that elevated IGF-1 concentrations have an impact on insulin secretion, which could, over time, lead to IR (22,26). It was shown that plasma IGF-1 concentration was increased in

![Table 1](Image)

**Table 1**

<table>
<thead>
<tr>
<th>State</th>
<th>GIR (mg/kg/min)</th>
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<tbody>
<tr>
<td>Ideal (GIR 1)</td>
<td>28.8 ± 0.9</td>
</tr>
<tr>
<td>Obese (GIR 2)</td>
<td>15.3 ± 0.3</td>
</tr>
<tr>
<td>Weight reduced (GIR 3)</td>
<td>22.7 ± 0.7</td>
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<tr>
<td>(GIR 2–GIR 1)/GIR 1</td>
<td>−43%</td>
</tr>
<tr>
<td>(GIR 3–GIR 1)/GIR 1</td>
<td>−17%</td>
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1 n = 6; values are means ± SEM.
2 Significantly different from the other two times (P < 0.05) based on Wilcoxon paired test.
insulin-resistant patients (27). This could have different effects. Because of its structural homology with insulin, IGF-1 can link to insulin receptors and then lead to a decrease in insulin resistance (28). Otherwise IGF-1 acts as a mitogenic factor and can stimulate β-cell proliferation and then insulin secretion (29). It was shown that impairment in both TNFα and IGF-1 plasma concentration are associated with insulin resistance, in obese dogs, and this could explain, at least in part, the outbreak of this syndrome (15). Our results showed that the treatment of obesity could allow a return of these variables to normal levels, as previously demonstrated in humans (9). This showed that the changes in glucose metabolism observed in obese dogs suffering from a nutritional obesity are reversible, and the treatment of obesity is beneficial to the long-term health of these animals. Because it occurred rapidly in response to restriction of energy intake we can hypothesize that the return of TNFα and IGF-1 concentrations to normal values would have been the consequence of this restriction rather than decrease in adiposity.

In conclusion, this study showed that the high protein-energy-ratio, low-energy, high-fiber L-carnitine–enriched diet used here allowed a very rapid weight loss in obese dogs, without alteration in body composition compared to their ideal state. It also suggested that the treatment of obesity in dogs could be a factor in normalizing levels of insulin resistance.

LITERATURE CITED