Fiber But Not Conjugated Linoleic Acid Influences Adiposity in Dogs*

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CLINICAL RELEVANCE

Feeding obese dogs a high-fiber food with or without added conjugated linoleic acid (CLA) resulted in reduced caloric consumption, reduced body weight, and a 3.3% reduction in body fat, whereas feeding a low-fiber food resulted in a comparable increase in caloric consumption and a 2.4% gain in body fat. The addition of CLA did not significantly affect food intake, energy intake, final lean body percent, change in lean body percent, or final fat percent. These results suggest that the addition of dietary fiber but not CLA to foods may be helpful in the treatment of canine obesity.

INTRODUCTION

Epidemiologic evidence indicates that 25% of dogs and cats seen by veterinarians in the United States are either overweight or obese. Obesity is a health problem of appreciable magnitude because it has been linked directly to many chronic diseases and increased mortality. Scarlett and Donoghue found that overweight cats are nearly four times more likely to develop diabetes mellitus and three times more likely to become lame and have an increased incidence of nonallergic skin disease. Furthermore, the risk of death is nearly three times higher in middle-aged obese cats than in lean cats. Dogs also have health impairments associated with being overweight or obese. Overweight and obese dogs have an increased incidence of traumatic and degenerative orthopedic disorders, neoplasia, cardiovascular disorders, respiratory disease, hypertension, diabetes mellitus, and derma-
topathies, and their tolerance to weather extremes, anesthesia, and surgical procedures may be reduced. Energy restriction has been shown to delay signs of aging in dogs and increase longevity. In a 14-year-long pair-matched study, Labrador retrievers fed 25% less food than control dogs generally had a delayed onset of chronic diseases and a significantly increased median life span (11.2 versus 13.0 years).

Despite the potential for obesity prevention and treatment to decrease the risk of comorbidities and increase longevity, obesity is frequently underdiagnosed and consequently goes untreated. Therefore, dietary components that reduce an obese dog’s weight without calorically restricting meals could have the potential to significantly improve the health of the canine population. Diluting energy with fiber is a common strategy for inducing weight loss in dogs. Previously, we (D.E.J. and P.W.T.) reported that increasing the fiber content in dog food (<2% versus 12% or 21%, as fed) induced satiety and consequently reduced adiposity.

Recently, conjugated linoleic acid (CLA), a mixture of positional and geometric isomers of linoleic acid formed by rumen and colonic bacteria found in fat from ruminants, have been shown to reduce body fat and increase muscle mass in rats, mice, and pigs, even when fed ad libitum. Suggested mechanisms for this effect include inhibiting de novo lipogenesis, decreasing lipid deposition, and increasing lipolysis, mainly through competitive inhibition of enzymes involved in lipid metabolism. It has been reported that dogs that were significantly gaining fat and fed a medium-fiber food with dietary CLA had reduced fat accretion compared with dogs fed the same food without dietary CLA. To our knowledge, no study in dogs has been reported that has determined whether the addition of dietary fiber and CLA to foods would have additive, synergistic, or antagonistic effects on adiposity.

The objective of this study was to evaluate the separate and combined effects of dietary fiber and CLA on body composition of adult obese dogs.

**MATERIALS AND METHODS**

All protocols were approved by the University of Georgia Institutional Animal Care and Use Committee and the Hill’s Animal Care and Use Committee and complied with USDA guidelines for use of laboratory animals.

**Animals**

Twelve obese (initial body fat > 35%) intact female beagles older than 1 year participated in this study. All dogs were in good health and weighed approximately 15 kg. Six dogs were allotted to each of two treatment groups based on body weight and baseline body fat content. No significant difference existed between treatment groups in terms of body composition or age. Subjects were housed in pairs but fed individually. Environmental temperature was controlled between 20°C and 22°C. Dogs had unlimited access to water.

**Treatment Diets**

Treatments consisted of four experimental foods formulated to meet or exceed known canine daily nutrient allowances. Table 1 lists...
the ingredient and chemical composition of these foods. Foods 1 and 2 contained approximately 2% crude fiber, as fed. A feed-grade form of CLA (0.91% added with a concentration of 0.55% CLA, 0.14% trans-10, cis-12 isomer of CLA) replaced a portion of the soybean oil in Food 2 to achieve an active CLA level of 0.5%. Foods 3 and 4 contained approximately 22% crude fiber, as fed. Food 4 was also formulated to provide an active CLA level of 0.5%. To achieve the increased fiber levels in Foods 3 and 4, a fiber mixture containing peanut and soybean hulls was substituted for all of the rice and a portion of the corn in Foods 1 and 2 (Table 1); dietary calcium was added to Foods 1 and 2 to offset the calcium differences caused by the addition of fiber to Foods 3 and 4. The CLA preparation was shown previously to reduce fat mass in rats. The energy concentrations of the foods were 3.75 kcal metabolizable energy (ME)/g for the low-fiber food and 2.93 kcal ME/g for the fiber-enhanced food.

**Experimental Design**
A mixed model design was conducted in which 12 animals were randomly allocated to one of two fiber groups (six to the high-fiber group and six to the low-fiber group). Three dogs in each fiber group were randomly selected to receive no CLA for 3 months. At the end

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**TABLE 1. Ingredient and Chemical Composition of Experimental Foods**

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Food 1 (low fiber)</th>
<th>Food 2 (low fiber + CLA&lt;sup&gt;a&lt;/sup&gt;)</th>
<th>Food 3 (high fiber)</th>
<th>Food 4 (high fiber + CLA&lt;sup&gt;a&lt;/sup&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>30.0</td>
<td>30.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Corn</td>
<td>38.5</td>
<td>38.5</td>
<td>30.8</td>
<td>30.8</td>
</tr>
<tr>
<td>Fiber mix (peanut and soybean hulls)</td>
<td>0.0</td>
<td>0.0</td>
<td>37.8</td>
<td>37.8</td>
</tr>
<tr>
<td>Poultry by-products</td>
<td>21.5</td>
<td>21.5</td>
<td>21.3</td>
<td>21.3</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>7.0</td>
<td>7.0</td>
<td>7.3</td>
<td>7.3</td>
</tr>
<tr>
<td>Soybean oil</td>
<td>2.2</td>
<td>1.29</td>
<td>2.2</td>
<td>1.29</td>
</tr>
<tr>
<td>CLA oil mix</td>
<td>—</td>
<td>0.91</td>
<td>—</td>
<td>0.91</td>
</tr>
<tr>
<td>Vitamins and minerals</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Calcium carbonate</td>
<td>0.2</td>
<td>0.2</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

**Chemical composition (%)**

<table>
<thead>
<tr>
<th></th>
<th>Food 1 (low fiber)</th>
<th>Food 2 (low fiber + CLA&lt;sup&gt;a&lt;/sup&gt;)</th>
<th>Food 3 (high fiber)</th>
<th>Food 4 (high fiber + CLA&lt;sup&gt;a&lt;/sup&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLA</td>
<td>0</td>
<td>0.5</td>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>Moisture</td>
<td>9.0</td>
<td>10.0</td>
<td>8.3</td>
<td>7.5</td>
</tr>
<tr>
<td>Crude fiber</td>
<td>2.0</td>
<td>2.1</td>
<td>22.4</td>
<td>22.3</td>
</tr>
<tr>
<td>Protein</td>
<td>22.1</td>
<td>21.7</td>
<td>21.5</td>
<td>21.6</td>
</tr>
<tr>
<td>Fat</td>
<td>4.2</td>
<td>4.1</td>
<td>5.0</td>
<td>5.0</td>
</tr>
</tbody>
</table>

<sup>a</sup>Conjugated linoleic acid (CLA) mixture (0.91%) was added to foods 2 and 4 to achieve an effective level of 0.5%.
of that time, these three dogs were then fed CLA-enriched food for an additional 3 months. Conversely, the other three dogs in the fiber group were randomly selected to receive CLA-enriched food at the beginning of the study; after 3 months, these dogs were then fed food with no CLA for 3 more months. Individual dogs were given free access to food for 45 to 60 minutes at the same time each day. Amounts eaten were recorded daily.

Each dog’s body composition was assessed at the beginning of the study and on days 90 and 180 using dual energy x-ray absorptiometry (QDR 100W, Hologic, Waltham, MA).

Statistical Analysis

Statistical analysis was completed using PROC MIXED (SAS/STAT User’s Guide, Version 9, 2004, SAS Institute, Cary, NC) to evaluate the separate and joint effects of fiber and CLA. Fiber was treated as a discrete independent between-subjects variable. CLA was treated as a discrete repeated measures within-subjects variable. The covariance matrix was estimated using the Toeplitz method to provide a correct denominator for testing the hypotheses. PROC MIXED made the appropriate adjustment to degrees of freedom. Initial body fat percentage was used as a covariate for the body weight and body composition analysis, whereas metabolic size (weight in kilograms raised to the 0.75 power) was used as a covariate for the food intake analysis. Least squares means and appropriate SE from PROC MIXED were presented. A significant effect occurred on the analyzed response variable if there was a significant probability ($P \leq .05$) associated with the effect of either CLA or fiber. A trend toward significance was noted when the probability associated with the effect was greater than $P = .05$ and less than $P = .1$.

RESULTS

All subjects completed the study, remained in good health, and readily accepted the foods provided.

Dogs fed the low-fiber foods had a lower average daily intake of food on a gram basis than dogs fed the high-fiber foods (Table 2). On an energy basis, however, dogs fed the low-fiber foods consumed more calories than dogs fed the high-fiber foods. CLA had no effect on average food intake on a gram or energy basis (Table 2).

Table 3 shows the effect of treatments on body composition. At the end of the feeding period, average body weight was higher for dogs in the low-fiber groups (16.2 kg) than for those in the high-fiber groups (14.0 kg) ($P < .05$). There was no significant difference in average body weights resulting from an effect of CLA. Dogs in the low-fiber groups gained an

<table>
<thead>
<tr>
<th>Table 2. Effect of Dietary Fiber and CLA on Daily Food and Metabolizable Energy (ME) Intake (least squares means ± SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low-Fiber Foods</strong></td>
</tr>
<tr>
<td>Intake (g/d)</td>
</tr>
<tr>
<td>ME (kcal/d)</td>
</tr>
</tbody>
</table>

$^a$The difference in daily food intake on a gram basis was not significant for dogs fed the low- or high-fiber foods. The difference in kilocalories consumed daily, however, was significant ($P \leq .05$). Conjugated linoleic acid (CLA) had no significant effect on grams of daily food intake or kilocalories consumed.

$^b,c$Means in a row with different superscripts are significantly different ($P \leq .05$).
average of 1.2 kg of body weight and lost an average of 3.3% lean body mass, whereas those in the high-fiber groups lost an average of 0.8 kg of body weight and increased lean body mass by an average of 2.4% over the course of the study. Addition of CLA to either the low- or high-fiber foods had no effect on change in body weight, final lean body mass, or change in lean body mass (Table 3).

Body fat increased an average of 3.3% in dogs fed the low-fiber foods, whereas dogs in the high-fiber group lost an average of 2.4% body fat over the course of the study (Table 3). Dogs fed low-fiber foods had an average final body fat percentage of 38.7% versus 31.1% for dogs fed the high-fiber foods ($P \leq .05$). CLA had no significant effect on body fat composition (final fat percent or change in body fat percent, Table 3).

### DISCUSSION

Fiber has a long history as a food energy dilutor and is extensively used for the prevention and treatment of obesity. Studies have shown that CLA reduces fat accumulation and increases lean muscle mass in several animal models, including rats, pigs, chickens, and mice. Although comparable studies using dogs have not been published, the effects of CLA related to fat accrual and nutrient partitioning are especially intriguing given the high prevalence of obesity in the canine population. The primary objective of this study was to determine whether dietary fiber and/or CLA attenuated food intake, body composition, and/or weight gain in obese dogs.

The biologic effects of CLA may be affected by many variables, including species and degree of obesity. In some studies, mice fed CLA had 70% to 80% less body fat than controls. Other studies demonstrated a less robust average body fat reduction of approximately 50%. Rats are generally less responsive to CLA than mice; rats fed CLA-enriched diets typically average 15% to 25% less body fat than controls. In one study, CLA included in the diet at 0.5% reduced adiposity in lean but not obese Zucker rats. CLA had no effect on rats in which obesity was already established. Feeding CLA to growing pigs has resulted in a significant reduction in back fat thickness (−27%) and an increase in lean body mass (−5%), but this may be only in pigs with higher body fat levels. Similar results would

### TABLE 3. Final and Changes in Body Weight and Composition of Dogs Fed Foods Containing Low or High Fiber with and without CLA (least squares means ± SE)

<table>
<thead>
<tr>
<th></th>
<th>Low-Fiber Foods</th>
<th>High-Fiber Foods</th>
<th>No CLA</th>
<th>With CLA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final body weight (kg)</td>
<td>16.2 ± 0.4$^a$</td>
<td>14.0 ± 0.4$^b$</td>
<td>15.1 ± 0.3</td>
<td>15.1 ± 0.4</td>
</tr>
<tr>
<td>Change in body weight (kg)</td>
<td>1.2 ± 0.3$^a$</td>
<td>−0.8 ± 0.3$^b$</td>
<td>0.4 ± 0.2</td>
<td>0.1 ± 0.4</td>
</tr>
<tr>
<td>Final lean body mass (%)</td>
<td>59.8 ± 1.9$^a$</td>
<td>67.2 ± 1.9$^b$</td>
<td>63.3 ± 1.8</td>
<td>63.7 ± 1.6</td>
</tr>
<tr>
<td>Change in lean body mass (%)</td>
<td>−3.3 ± 1.6$^c$</td>
<td>2.4 ± 1.6$^d$</td>
<td>−0.8 ± 1.8</td>
<td>−0.1 ± 1.6</td>
</tr>
<tr>
<td>Final fat (%)</td>
<td>38.7 ± 1.9$^a$</td>
<td>31.1 ± 1.9$^b$</td>
<td>35.1 ± 1.9</td>
<td>34.7 ± 1.6</td>
</tr>
<tr>
<td>Change in fat (%)</td>
<td>3.3 ± 1.6$^c$</td>
<td>−2.4 ± 1.6$^d$</td>
<td>0.8 ± 1.7</td>
<td>0.1 ± 1.7</td>
</tr>
</tbody>
</table>

$^a,b$ Means in a row with different superscripts are significantly different ($P \leq .05$).

$^c,d$ Means in a row with different superscripts have a trend toward a significant difference ($P = .06$).

CLA = conjugated linoleic acid.
be expected in growing puppies as CLA seems to have increased efficacy in animals accreting body fat. Results of studies in humans have been mixed. Human adults fed CLA for 12 weeks had reduced fat mass and increased lean mass. In another study, investigators observed no significant effect on fat mass. Our results are similar to those found in obese Zucker rats and in people in whom CLA had no effect. That is, CLA had no effect on food intake or body composition irrespective of the fiber level in the foods provided.

Dogs in optimal body condition have 15% to 25% body fat. Overweight dogs have compositions of more than 25% fat, and obese dogs are typically defined as those with a body fat mass exceeding 35%. The body composition data obtained by dual energy x-ray absorptiometry indicate that the dogs enrolled in this study were initially overweight or obese according to this definition. The level of obesity increased in dogs fed low-fiber foods but decreased in those fed the high-fiber foods.

Commercial weight-reduction foods typically dilute energy with fiber, water, or air. Such foods are generally fed to provide 50% to 60% of an obese dog’s daily energy requirement calculated at normal body weight. Veterinarians treating obese dogs usually recommend an exercise component to increase caloric expenditure. Exercise as a means to facilitate weight loss was not included in our study design. The experimental foods used in this study were not fed to reduce caloric intake but rather were fed ad libitum. Consequently, dogs in this study were not forced to lose weight. In this situation, CLA had no effect; the statistically significant differences in reduced energy consumption and the resulting changes in body composition (loss of fat mass and increase in lean body mass) in obese beagles were induced by increased dietary fiber content. In most studies in which positive effects of CLA were obtained, the study subjects were growing. CLA seems to work best when animals are actively accruing fat. Whether CLA is effective in adult dogs fed for weight loss was not a part of this study.

The increase in dietary fiber, which was accomplished by replacing rice, significantly reduced voluntary energy intake. This reduction effectively and significantly changed body composition (decreased fat mass and increased lean body mass). The increase in lean body mass is important because muscle is more metabolically active than fat. This fact proba-
the daily meal. In that study, a high-fiber food (~21% dietary fiber, as fed) clearly decreased hunger and enhanced satiety, as shown by decreased caloric intake in both the daily and intruded meals. Other studies substituting fiber for either high-starch or high-fat ingredients have since confirmed the importance of dietary fiber in promoting satiety and weight loss. Since commercial foods with increased dietary fiber content are readily available, they provide an attractive solution to treating obesity and aiding in the prevention of adipose tissue gain. Obesity in people causes about 300,000 deaths per year, and its related health care costs are estimated at $100 billion annually in the United States alone. Similar numbers are unavailable for dogs and cats. However, many of the risk factors that predispose humans to obesity also frequently apply to dogs and cats. Among these are unlimited access to highly palatable, energy-dense foods and reduced physical activity. Unfortunately, many people substitute food and treats for more healthful interactions with their pets. Consequently, obesity risk factors for pets and people within the same household often overlap. Most weight-reduction programs for dogs and cats fail, as do their human counterparts. Many pet owners lack the discipline to feed a food with restricted energy in controlled amounts and implement an exercise program for the many months that it may take a pet to achieve a healthy body composition. Consequently, foods with components such as increased dietary fiber that may prevent obesity or lead to spontaneous loss of body weight and fat mass in dogs despite ad libitum consumption may be useful when pet owners lack the discipline to adhere to more conventional weight-reduction programs.

CONCLUSION

Obesity puts dogs at increased risk for various diseases and is associated with increased mortality. As is seen in other species studied to date, reduction in caloric intake increases the median life span of dogs. In this study, increased dietary fiber reduced energy intake and adiposity of obese adult dogs. In contrast, CLA, included at 0.5% of the diet, had no effect on daily energy consumption and body composition. These findings demonstrate that, in obese dogs, increasing levels of dietary fiber induce a reduction in food intake and, thus, lead to reduced body fat mass in dogs; CLA appears to have no beneficial effect.

ACKNOWLEDGMENTS

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REFERENCES