Domestic Animal Endocrinology 49 (2014) 70–79

Contents lists available at ScienceDirect

Domestic Animal Endocrinology

journal homepage: www.domesticanimalendo.com

Metabolic determinants of body weight after cats were fed a low-carbohydrate high-protein diet or a high-carbohydrate low-protein diet ad libitum for 8 wk

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ARTICLE INFO

Article history:
Received 6 January 2014
Received in revised form 1 June 2014
Accepted 1 June 2014

Keywords:
Fat mass
Weight gain
Energy requirement
Glucose
Adipocytokines
Cat

ABSTRACT

Overweight and obese conditions are common in cats and are associated with the development of a number of diseases. Knowledge of metabolic determinants and predictors of weight gain may enable better preventative strategies for obesity in cats. Lean, healthy cats were fed either a low-carbohydrate high-protein diet (n 16) or a high-carbohydrate low-protein (n 16) diet ad libitum for 8 wk. Potential determinants and predictors of final body weight assessed were body fat and lean masses, energy required for maintenance, energy requirements above maintenance for each kilogram of weight gain, insulin sensitivity index, fasting, mean 24-h and peak plasma glucose, insulin, and leptin concentrations, and fasting and mean 24-h serum adiponectin concentrations. In cats fed the low-carbohydrate high-protein diet, after adjusting for initial body weight, those with higher energy requirements for weight gain and higher fasting glucose concentration had higher final body weights ($P \leq 0.01$). Predicted final body weights using initial body weight, fasting glucose and mean 24-h insulin concentrations (partial R^2 37.3%) were imprecise. An equation using just initial body weight and fasting glucose concentration would be of more practical value, but was marginally less precise. In cats fed the high-carbohydrate low-protein diet, those with lower fasting leptin concentration initially had higher final body weights ($P = 0.01$). Predicted final body weights using initial body weight, energy requirements for maintenance, total body fat percentage and fasting leptin concentration (partial R^2 39.2%) were reasonably precise. Further studies are warranted to confirm these findings and to improve the precision of predicted final body weights.

1. Introduction

Overweight and obese conditions are commonly recognized in pet cats around the world and are associated with the development of a number of diseases, including diabetes mellitus [1]. Although the prevalence of overweight and obese cats varies according to the population studied and methods used to determine body condition, the overall incidence is high in developed countries, varying from 17% to 63% [2–5].

As in humans [6], genetic and environmental factors are believed to predispose cats to weight gain. Environmental factors such as indoor housing [7], ad libitum feeding [8], neutering [4,7,8] and the underestimation of body condition status by owners [3] have been identified as risk factors for obesity in cats. Genetic factors determine the magnitude of weight gain in the presence of excess food [9].

In adult humans, recognized predictors of weight gain are low metabolic rate, low levels of physical activity, low

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http://dx.doi.org/10.1016/j.domaniend.2014.06.001

rates of fat oxidation, low sympathetic nervous system activity and low fasting plasma leptin concentrations [10]. There is controversy in relation to the predictive value of insulin sensitivity in relation to weight gain in humans; in some populations increased insulin sensitivity is associated with weight gain, in others there is no association [10,11]. Similarly, decreased fasting insulin concentration has been reported to be associated with subsequent weight gain in some studies [12,13], whereas no association has been found in others [11].

There are no published studies investigating metabolic determinants of weight gain in cats. It is known that most of the excess weight in adult overweight and obese cats is from body fat [14,15] and increased adipose tissue mass is associated with reduced insulin sensitivity [16,17], increased circulating leptin [18–20], and decreased total adiponectin concentrations in cats [18]. These parameters might be useful markers for the prediction of weight gain in cats.

Better knowledge of metabolic factors associated with weight gain may help explain why some cats gain weight more easily than others and may enable more effective preventative strategies for obesity in cats. The aims of this study were to identify metabolic determinants of final body weight after 8 wk of ad libitum feeding in clinically healthy cats, and to identify predictive equations that could be used prospectively to identify cats that are likely to gain the most weight when fed ad libitum.

2. Materials and methods

2.1. Study overview

A retrospective single cohort study was conducted using data from a controlled trial. Cats were fed either a low-carbohydrate high-protein diet or a high-carbohydrate low-protein diet ad libitum for 8 wk. Potential determinants and predictors of final body weight were assessed using linear regression. Variables assessed were initial body fat and lean masses, initial maintenance energy requirements, energy requirements above maintenance for each kilogram of body weight gain, insulin sensitivity index, and fasting, mean 24-h and peak plasma glucose, insulin and leptin concentrations, and fasting and mean 24-h serum adiponectin concentrations. Initial body weight was fitted in all models.

Testing protocols, cat signalment, body condition variables, and insulin and glucose concentrations have been previously reported as part of a study to assess effects of weight gain and diet on glucose and insulin concentrations [15], also on leptin and adiponectin concentrations [20] and in a study to assess the effect of dietary carbohydrate intake on adiponectin profiles [21]. Leptin and adiponectin concentrations have been reported in Coradini et al [20] and part of the adiponectin results have been reported in Tan et al [21]. Thirty-two neutered, lean, mixed breed and clinically healthy cats (16 males, 16 females) of approximately 2 to 4 yr of age, were used in the study. Mean body weight was 3.31 kg (range 2.42–4.64 kg) and mean body condition score was 4.9 (range 4–5) on a 9-point body condition system [22]. Full description of the study protocol and dietary analyses have been reported [15].

The study consisted of 3 phases: baseline, stable-weight and weight-gain. In the baseline phase, all cats were fed a baseline diet, moderate in carbohydrate, fat, and protein (Table 1) [15], to maintain their body weight within 95% to 105% of their initial weight for 3 wk, and tests were conducted in the fourth week. Cats were paired based on sex, insulin sensitivity and body weight, and were then randomly allocated to 1 of 2 diets, a low-carbohydrate, moderate-fat and high-protein diet, or a high-carbohydrate, moderate-fat and low-protein diet (Table 1) [15].

In the stable-weight phase, cats were fed either a low-carbohydrate high-protein or a high-carbohydrate low-protein diet to maintain their body weight within 95% to 105% of their initial weight for the following 4 wk (study weeks 5–8), with testing in the eighth week of the study. In the weight-gain phase, cats were fed their respective test diets ad libitum for the subsequent 8 wk (weeks 9–16) and were tested in the 17th week of the study. During test weeks, cats were fed their maintenance energy requirements to allow comparison of results between the stable-weight and weight-gain phases and to determine the effects of 8 wk of ad libitum feeding on the parameters tested [15].

All diets used were commercially available extruded dry feline products made to comply with the Association of American Feed Control Officials standards. The study protocol, care and handling of the animals was approved by the University of Queensland's Animal Ethical Review

Table 1
Macronutrient distributions and energy densities of the baseline, low-carbohydrate high-protein and high-carbohydrate low-protein diets.

Approximate energy (ME)	Diet		
	Baseline[a]	Low carbohydrate[b]	High carbohydrate[c]
Energy density kJ/100g[d]	1518.0	1552.0	1550.0
Energy density kJ/100g[e]	1427.0	1434.0	1478.0
Protein (%)[e]	29.4	47.0	21.3
Fat (%)[e]	27.4	29.8	28.2
Carbohydrate (%)[e]	43.2	23.3	50.5

Abbreviation: ME, metabolizable energy.
Composition values are expressed as percentage contribution to total metabolizable energy.
[a] Whiskas Adult with Vita-Bites, Mars Petcare, Raglan New South Wales Australia.
[b] Royal Canin Diabetic Feline, Royal Canin, Aimargues, France.
[c] Kitekat Krunch, Mars Petcare, Raglan, New South Wales, Australia.
[d] Metabolizable energy calculated using the equation proposed by the National Research Council, 2006 [40].
[e] Metabolizable energy calculated using the modified Atwater factors, National Research Council, 1985 [41].