Effectiveness of a New Weight Management Food to Achieve Weight Loss and Maintenance in Client-owned Obese Dogs

Undine Christmann, DVM, PhD, DACVIM*

Iveta Bečvářová, DVM, MS, DACVN

Stephen Werre, PhD

Hein P. Meyer, DVM, PhD, DECVIM

From the Department of Population Health Sciences (Christmann) and the Laboratory for Study Design and Statistical Analysis (Werre), Virginia-Maryland Regional College of Veterinary Medicine, Duck Pond Drive, Phase II, Blacksburg, VA 24061, USA; and Hill's Pet Nutrition – Europe, Middle East & Russia, Rohanské nábřeží 678/23, Karlín, Prague 8, 186 00, Czech Republic (Bečvářová, Meyer).

Address correspondence to Dr. Christmann at undine.christmann@lmunet.edu

* Dr. Christmann's new address is: Lincoln Memorial University College of Veterinary Medicine, DeBusk Veterinary Teaching Center, 203 DeBusk Farm Lane, Ewing, VA 24248

KEY WORDS: overweight/obesity, diet, weight loss, weight management, nutrigenomics

ABSTRACT

Objective- To evaluate weight loss and maintenance parameters in dogs fed a new weight management food (NWMF) and to assess the owner's perception of the dog's quality of life.

Design- Prospective, uncontrolled/unmasked clinical trial.

Animals- One hundred sixty two overweight/obese, otherwise healthy, client-owned dogs.

Procedures- Initial evaluation included physical examination, nutritional assessment, ideal body weight (IBW) determination, and weight-loss feeding guidelines development. Monthly follow-up evaluations (for 6 months) encompassed determination of BW, body condition score (BCS), body fat index (BFI), muscle condition score (MCS), and feeding practices. Quality of life assessment by owners included dog's level of energy, happiness, appetite, begging behavior, flatulence, stool volume, and fecal score.

Results- Ninety four percent of the dogs lost weight with an average weight loss of 14.5% (SEM, 1.1%) over 6 months and an average weekly weight-loss rate of 0.7% (SEM, 0.04%). The mean weight loss period duration was 127 days (SEM, 4.3 days). Thirty nine percent of dogs achieved IBW (0.39, CI: 0.31-0.48) over the study's course. Fifty five percent of dogs ate more calories from NWMF than the recommended daily energy requirement for weight loss, the majority of these dogs still lost weight. BCS and BFI decreased over time compared to baseline. Owners perceived an increase in energy and happiness in the dogs that lost weight without changes in appetite or begging behavior.

Conclusions and Clinical Relevance- This study confirmed the effectiveness of the

NWMF in weight management of client-owned dogs. Owners reported significant improvements in dog's quality of life without negative side effects.

ABBREVIATIONS

BCS   Body condition score

BFI   Body fat index

BW   Body weight

CI   Confidence interval

DER   Daily energy requirement for weight loss calculated as 1x (70 x $IBW_{kg}^{0.75}$)

IBW   Ideal body weight

LSM   Least square mean

MCS   Muscle condition score

NWMF New weight management food

RER   Resting energy requirement

SD   Standard deviation

SEM   Standard error of the mean

INTRODUCTION

The prevalence of overweight or obesity in pet dogs is estimated to be close to 50-60% according to recent publications and surveys.[1,2, a] Overweight or obesity is the most common nutritional disorder in dogs.[3] Increased adiposity predisposes pets to a number of other diseases, and decreases quality of life and longevity in affected animals.[1,3-5] Effective weight loss programs should be tailored to achieve a safe, consistent rate of weight loss, to maintain a healthy weight in pets after weight loss, and to improve the dog's quality of life. These programs are typically composed of a combination of :

1) caloric restriction 2) selection of an appropriate food 3) increase in the dog's activity level 4) behavioral modification of the dog and dog's owner.[2]

Achieving successful weight loss in clinical practice represents a particular challenge because: 1) it is difficult to estimate ideal body weight, especially in extremely obese dogs 2) maintaining owner compliance with the imposed feeding restriction and without frequent supervision is an issue 3) dogs that achieve the desired target weight are at high risk of regaining weight during the weight maintenance phase if new feeding habits are abandoned long-term.[6-8]

In response to this challenge, a new weight management food (NWMF)[b] was developed with the following goals: 1) to induce effective weight loss in client-owned obese/overweight dogs under real life household conditions 2) to reduce the effect of compliance issues 3) to maintain body weight past the weight loss phase without the need to change food.

NWMF was designed as a reduced calorie, reduced fat, increased fiber food containing a synergistic blend of ingredients/nutrients based on nutrigenomic technology (see Table 1a and 1b) and formulated for both weight loss and long-term weight maintenance. Overweight/obese dogs in an experimental setting were previously shown to have modified gene expression during the weight loss and maintenance phase while being fed the NWMF.[9-11] Two experimental studies in dogs fed NWMF revealed a weight loss rate up to of 1.5% BW per week, maintenance of the new weight, and modified expression of genes that play a key role in amino acid, glucose and fat metabolism.[9,12]

In another 2-month-long weight loss study, client-owned overweight/obese dogs (n=159) fed NWMF achieved weight loss with a weight loss rate of 0.8% initial BW per week.[13] However, this study was short in duration and did not evaluate weight maintenance.

The purpose of this study was to determine the effectiveness of NWMF in achieving weight loss and maintenance in overweight/obese, client-owned dogs, under typical household conditions. The objectives were: 1) to evaluate weight loss and maintenance parameters in dogs fed a NWMF 2) to assess the owner's perception of the dog's quality of life.

MATERIALS AND METHODS

Eligibility Criteria for Dogs-

Dogs were recruited through private and university practices from different European countries participating in the study. Client-owned dogs were eligible for inclusion in the study based on physical examination and nutritional screening evaluation.[14] Inclu-

Table 1a. *List of ingredients contained in the new weight management food (NWMF):*

Wheat, poultry meat meal, maize gluten meal, maize, pea bran meal, soybean meal, cellulose, tomato pomace, digest, flaxseed, beet pulp, animal fat, coconut oil, minerals, DL-methionine, L-lysine, carrots, L-carnitine, rice, vitamins, taurine, trace elements, L-tryptophan, beta carotene. Naturally preserved with mixed tocopherol and citric acid.

Table 1b. *Average nutrient content in the new weight management food (NWMF).*

Criterion	Dried ration		
	As fed	Dry matter	Per 100 kcal ME
Protein	26.2 %	28.6 %	8.4 g
Fat	11.0 %	12.0 %	3.5 g
Carbohydrate (NFE)	36.0 %	39.3 %	11.6 g
Fiber (crude)	13.1 %	14.3 %	4.2 g
Total dietary fiber	23.8 %	26.0 %	7.6 g
Moisture	8.5 %	-	2.7 g
Calcium	0.77 %	0.84 %	247 mg
Phosphorus	0.61 %	0.67 %	196 mg
Sodium	0.27 %	0.30 %	87 mg
Potassium	0.82 %	0.90 %	263 mg
Magnesium	0.13 %	0.14 %	42 mg
Omega-3 fatty acids	0.69 %	0.75 %	221 mg
Omega-6 fatty acids	1.92 %	2.10 %	616 mg
Taurine	1,006 mg/kg	1,099 mg/kg	32 mg
L-carnitine	287 mg/kg	314 mg/kg	9 mg
L-lysine	1.60 %	1.75 %	514 mg
Vitamin A	7,040 IU/kg	7,694 IU/kg	226 IU
Vitamin D	697 IU/kg	762 IU/kg	22 IU
Vitamin E	500 mg/kg	546 mg/kg	16 mg
Vitamin C	90 mg/kg	98 mg/kg	3 mg
Beta-carotene	1.5 mg/kg	1.6 mg/kg	0.5 mg
Metabolizable Energy			
Kcal/100g	311	340	
KJ/100g	1,302	1,423	

NFE: nitrogen free extract, ME: metabolizable energy

sion criteria for dogs were as follows: 1) at least 1 year of age 2) considered generally healthy 3) overweight or obese with a body condition score (BCS) above 3 (on a 5 point scale).[15] Due to the duration of the study (6 months), it was recommended to limit enrollment to animals with a body fat index (BFI) of less than 50.[16]

Dog owners submitted their written consent to participate in the study and had to give their agreement to: 1) feed the recommended amount of NWMF (see Table 1a and 1b) dry food for the duration of the study 2) return to the clinic for re-check evaluations at monthly intervals for 6 months 3) report any relevant health issues during the study period.

Dogs were not eligible for the study if they: 1) were pregnant or lactating or expected to become pregnant during the study 2) had a history of adverse reactions to food 3) required urinary acidifiers during the study 4) needed another dietetic pet food 5) were expected to undergo surgery during the

study, or 6) participated in another clinical study.

Study Protocol-

The study was designed as a prospective, uncontrolled, unmasked clinical trial.

Initial evaluation of dogs enrolled in the study was comprised of physical examination, nutritional assessment screening evaluation, and determination of body weight (BW), BCS, body fat index (BFI[16]), muscle condition score (MCS – table 2), and evaluation of feeding practices.[14,16] Ideal body weight (IBW) was estimated using the Hill's BFI risk chart or an on-line Healthy Weight Protocol tool.[c 16] Daily energy requirement (DER) for weight loss was calculated as $DER = 1 \times RER = 1 \times (70 \times IBW_{kg}^{0.75})$.[2]

The importance of a healthy weight and the health risks for an overweight/obese dog were discussed with owners. Feeding guidelines to achieve IBW and maintain the newly acquired healthy weight were developed and explained to the owner. The owners were instructed to feed the NWMF and to avoid excess of additional treats, pet foods, or people foods. However, specific recommendations or restrictions about the amount and type of additional foods were not given. The expected rate of weight loss and target date for reaching IBW were reviewed with the owner. Owners were instructed to adjust the feeding amount for weight maintenance once the pet reached IBW. Feeding amount was determined using caloric allocation calculated as $DER = 1.6 \times RER = 1.6 \times (70 \times IBW_{kg}^{0.75})$.[17] NWMF was dispensed with feeding instructions, including the recommended amount of the dry food to be fed in grams per day, and how to gradually introduce the new food during a one-week period.

Follow-up assessments (monthly for 6 months) encompassed evaluation of BW, BCS, BFI, MCS, and review/readjustment of feeding practices. Owners were asked to describe their dog's quality of life on initial and during follow-up visits using a newly developed questionnaire, which allowed scoring of different criteria using an 11-point or 5-point Likert-type rating scale.

Owners scored their dog's level of energy, happiness, appetite, begging behavior, flatulence, and stool volume on an 11-point scale. For energy levels, a score of 0 was considered lethargic, whereas a score of 10 was attributed to hyper-excited dogs. Happiness scores ranged from sad (0/10) to very happy (10/10). Appetite scores extended from inappetant (0/10) to ravenous appetite (10/10) with 5/10 being normal. Begging behavior could vary from no begging (0/10) to constant begging (10/10). Similarly, flatulence scores reached from no flatulence (0/10) to severe flatulence (10/10) and stool volume levels ranged from small (0/10) to very large (10/10). A 5-point scoring system was used for fecal scores with 1/5 being watery feces and 5/5 being hard and dry stool (adapted from Jergens et al).[18]

Statistical Analysis-

At each follow-up time point, percent weight loss was computed as ((baseline BW – current BW)/baseline BW) x100. For each animal, a scatter plot of percent weight loss or weight gain vs weeks of follow-up was inspected to verify that the relationship was linear, followed by regression analysis. Animals with a positive slope were considered to have lost weight, those with a negative slope to have gained weight, while those with a slope of 0 were classified as dogs with no change in weight.

Slopes were collated and summarized as mean ± standard deviation. Other weight related continuous outcomes including duration of weight loss, average time that dogs were followed, average time between visits, time to achieve IBW, BW at start and end of study, and percent of BW lost (total) were also summarized as mean ± standard deviation or median (and range) as appropriate based on data distribution. Weight related categorical outcomes including dogs that achieved ideal BW (defined as a weight within IBW ± 9.9%* IBW, this formula was chosen because this is the smallest increment/decrement in weight that is known to be clinically noticeable) and dogs that still lost weight despite eating more than the DER were summarized as binomial pro-

portions with a 95% confidence interval. To assess changes in scores (BCS, BFI, MCS, energy, happiness, appetite, begging, flatulence, stool, and fecal scores) over time, least squares means at each time were compared using mixed model analysis of variance with animal ID as a random effect. Statistical significance was set at α=0.05. All analyses were performed using statistical software.[d]

RESULTS

Dogs

Dogs were recruited through private and university practices from 22 different European countries. One hundred sixty five dogs were enrolled into the study and 162 dogs were used for data analysis (data from 3 dogs was not included in the analysis since either only one data point was present or baseline data was missing). Some of the animals were lost to follow-up and part of the records had missing data in regard to one or more of the parameters to be assessed at one or more data collection points.

The number of data points per evaluation time for each parameter is detailed in the tables 5 and 6. Forty nine different breeds of dogs were represented in the study and accounted for 124 dogs (see Table 3). Thirty six dogs were mixed breeds, and the breed for two dogs was not indicated. Labrador retrievers represented the most frequent dog breed in the study with 27 dogs. A hundred and three dogs were female (of which 84 were neutered) and 50 dogs were male (of which 33 were neutered) (see Table 4). The sex was not reported for nine of the

Table 2. Muscle condition score (MCS): using visual examination and palpation over the temporal bones, scapulae, ribs, lumbar vertebrae and pelvic bones.[14]

Score	Description
1	No muscle wasting, normal muscle mass
2	Mild muscle wasting
3	Moderate muscle wasting
4	Marked muscle wasting

animals.

The median age was 6 years (range, 1 to 15 years) (Table 4).

There was a decrease in the number of dogs participating in the study over time.

With regard to weight loss related parameters and quality of life associated information, data was available for 151-161 dogs (minimum, maximum) on initial evaluation (Table 5 and 6), this number dropped to 135-161 dogs at week 4, 105-148 dogs at week 8, 105-124 dogs at week 12, 78-92 dogs at week 16, 60-75 dogs at week 20, and ended with 35-41 dogs at month 6.

Dietary Information Before the Study Started

Dog owners reported that they exclusively fed dry dog food to 120 dogs, whereas only 3 dogs received a food exclusively composed of wet food. Thirty-five dogs were fed a mixture of dry and wet food. Information on the type of food that was fed was unavailable for seven dogs.

Thirty two dogs were on a dietetic weight management food, 17 dogs were fed a wellness weight management food, and the rest of the dogs were fed a variety of other dog foods. Fifty four percent of the dogs were reported to be fed additional treats, foods or supplements. Due to the variety of information that was indicated in regard to food brands used and measurements used to determine the amounts of food fed, it was not possible to obtain a reliable estimate in regard to the caloric intake that was fed before the current study was started.

Weight Loss and Maintenance

The mean duration of weight loss was 127 ± 53 days (mean ± SD) with an average of 33 ± 13 days between visits. Ninety four percent of the dogs enrolled in the study lost weight (n = 153), 5% of the dogs gained weight (n = 8), and one dog maintained its weight (information for this dog is not included in Table 5 and 6). The average percentage of starting BW lost was 0.7% ± 0.5 per week when evaluated by using a linear regression model of the average percentage of weight loss by weeks enrolled in the

Table 3. *Participating dog breeds and number of dogs enrolled*

Breeds	# of dogs per breed
Alaskan malamute	1
American Staffordshire terrier	1
badger dog	1
Beagle	3
Bernese mountain dog	1
Bichon Frise	3
Border terrier	1
bouvier des Flandres	1
boxer	1
Brittany	1
bulldog	2
Cavalier King Charles spaniel	6
Chinese crested	1
Cocker spaniel	4
collie	1
dachsund	3
Dalmatian	2
English cocker spaniel	1
flat coated retriever	1
German shepherd dog	4
giant schnauzer	1
golden retriever	12
Irish setter	1
Labrador retriever	27
Lhasa Apso	3

Maltese	2
mastiff	1
miniature pinscher	1
miniature schnauzer	1
Newfoundland	2
pinscher	2
pit bull terrier	1
Prague ratter	1
pug	2
Pyrenean shepherd	1
retriever	4
Rottweiler	5
Jack Russel terrier	2
Saluki	1
Shi Tsu	1
Scottish terrier	1
Spanish water dog	1
springer spaniel	4
standard schnauzer	1
Weimaraner	1
Welsh corgi	1
West Highland white terrier	2
Yorkshire terrier	3
Purebred dogs	124
Mixed breeds	36
Breed not recorded	2
Total	**162**

study.

Fifty five percent of dogs in the study ate more than the daily energy recommendations (DER) for weight loss. The median percentage of caloric intake above DER for weight loss was 8.0 %. The majority of these dogs (94%, CI: 86.6% – 98.0%) still lost weight. The detailed results for weight loss characteristics are listed in Table 5. The least square mean (LSM) of weight of the dogs (in the group that lost weight) at the start of the study was 28.0 kg and was 23.5 kg at the end of the study. The weight achieved for each month was significantly different from the starting weight. In the group of dogs that gained weight, the LSM weight at the beginning of the study was 21.4 kg and 22.0 kg at

the end of the study. The mean percentage of weight loss for each group of dogs over time is indicated in Table 5.

The dogs lost approximately 1.1 % of starting body weight per week for the first 2 months and achieved a final 14.5% of weight loss at the end of the study.

Fifty seven dogs (39%, CI: 31.3% - 47.8%) achieved their ideal weight (IBW) during the study period. Twelve dogs reached their IBW at the last check-up examination performed as part of the study. The remaining 45 dogs maintained IBW on average for 72 days (range 17 – 190 days). Twenty one of these dogs reached their IBW at the 1st follow-up visit of the study.

Table 4. *Sex and age of dogs*

Dogs	Number
Sex	
Females (Neutered)	103 (84)
Males (Neutered)	50 (33)
Unknown	9
Age	
Mean (Range)	6.4 (1-15)

Evaluation of the 24 dogs that needed more than 1 follow-up examination to reach IBW revealed that all these dogs maintained their IBW and did so on average for 36 days (range 21-140 days).

The average time to achieve IBW was 72 days (SD, 44 days). Dogs that achieved IBW had a lower starting BCS than those that did not (median BCS 4 vs 5, p<0.0001). Body condition scores (BCS) decreased significantly over time compared to baseline in the group of dogs that lost weight. The BCS decreased by approximately 0.8 score from the beginning to the end of the study. BCS did not change significantly over time in the group of dogs that gained weight.

The body fat index (BFI) decreased significantly over time compared to baseline in the group of dogs that lost weight. The BFI decreased by approximately 11% from the beginning to the end of the study. BFI did not change significantly over time in the group of dogs that gained weight. The muscle condition score (MCS) decreased progressively over time compared to baseline in the group of dogs that lost weight. This decrease became statistically significant for week 16-24 when compared to the starting values. The MCS decreased by approximately 0.2 from the beginning to the end of the study. MCS did not change significantly over time in the group of dogs that gained weight.

Owner Assessments of Dogs' Quality of Life and Feces Characteristics

Energy scores significantly increased over time compared to baseline in the group of dogs that lost weight (Table 6). The energy scores, as perceived by the owner, increased by approximately 1.7 scores from the beginning to the end of the study. The energy score did not change significantly over time in the group of dogs that gained weight. Happiness scores significantly increased over time compared to baseline in the group of dogs that lost weight. The happiness scores increased by approximately 0.6 score from the beginning to the end of the study. The happiness score did not change significantly over time in the group of dogs that gained weight. Appetite scores and begging behavior, overall, did not change significantly over time compared to baseline in either groups of dogs.

There was a slight but statistically significant decrease in flatulence score in the group of dogs that lost weight. The average score was 2.8 at the beginning of the study and 2.1 at the end of the study. Similarly, there was a slight but statistically significant increase in the stool volume score and the fecal consistency score in the group of dogs that lost weight. The average stool volume score was 5.3 at the beginning of the study and 5.8 at the end of the study. The average fecal consistency score was 3.7 at the beginning of the study and 4.0 at the end of the study.

DISCUSSION

This study determined that feeding a new weight management food (NWMF) based on nutrigenomic technology effectively reduced excessive body weight and maintained healthy weight in client-owned obese/overweight dogs under typical household conditions. Weight loss parameters (BW, BCS, BFI) significantly improved over time compared to baseline and owners perceived a significant increase in energy and happiness of the dogs that lost weight without changes in appetite or begging behavior.

The average weekly weight-loss rate in our study (0.7% of starting BW) was slower than the desired goal of 1-2% weekly weight-loss but was consistent with results from other studies which evaluated weight loss in clinical practice.[2,7,8,19-21] This weight loss rate can be explained by a number of

Table 5. *Weight loss characteristics in dogs by week as measured for the dogs that lost weight or gained weight. Data is presented as least squares means or mean and standard error. The number of animals included in each measurement is indicated in parenthesis.*

		Weeks of the study						
		0	4	8	12	16	20	24
Body weight (kg)	LSM, SE							
Dogs that lost weight		28.05 ± 1.21	26.93 ± 1.21[a]	25.91 ± 1.21[a]	25.23 ± 1.2[a]	24.66 ± 1.21[a]	24.40 ± 1.21[a]	23.48 ± 1.22[a]
		(n=153)	(n=153)	(n=140)	(n=118)	(n=88)	(n=72)	(n=40)
Dogs that gained weight		21.4 ± 5.28	21.29 ± 5.28	22.07 ± 5.29	22.06 ± 5.29	21.86 ± 5.30	22.04 ± 5.3	21.99 ± 5.43
		(n=8)	(n=8)	(n=8)	(n=6)	(n=4)	(n=3)	(n=1)
Percentage weight lost	Mean, SE							
Dogs that lost weight		0	4.5 ± 0.36	7.77 ± 0.39	10.38 ± 0.54	12.19 ± 0.70	13.39 ± 0.74	14.56 ± 1.11
		(n=153)	(n=153)	(n=140)	(n=118)	(n=88)	(n=72)	(n=40)
Dogs that gained weight		0	0.32 ± 1.76	1.86 ± 1.03	2.23 ± 1.72	3.6 ± 1.23	5.61 ± 0.13	1.89 ± 0
		(n=8)	(n=8)	(n=8)	(n=6)	(n=4)	(n=3)	(n=1)
BCS	LSM, SE							
Dogs that lost weight		4.41 ± 0.05	4.27 ± 0.05[a]	4.02 ± 0.05[a]	3.84 ± 0.05[a]	3.71 ± 0.05[a]	3.71 ± 0.05[a]	3.62 ± 0.06[a]
		(n=150)	(n=145)	(n=132)	(n=112)	(n=82)	(n=65)	(n=36)
Dogs that gained weight		3.87 ± 0.21	3.87 ± 0.21	3.87 ± 0.21	3.89 ± 0.22	3.61 ± 0.25	3.61 ± 0.24	3.81 ± 0.27
		(n=8)	(n=8)	(n=8)	(n=6)	(n=4)	(n=3)	(n=1)
BFI	LSM, SE							
Dogs that lost weight		42.89 ± 1.01	40.28 ± 1.01[a]	37.38 ± 1.02[a]	35.64 ± 1.03[a]	33.72 ± 4.29[a]	32.05 ± 1.09[a]	31.23 ± 1.20[a]
		(n=138)	(n=132)	(n=123)	(n=103)	(n=78)	(n=63)	(n=33)
Dogs that gained weight		34.5 ± 4.19	34.5 ± 4.19	34.5 ± 4.19	33.66 ± 4.29	30.76 ± 4.47	32.53 ± 4.64	25.45 ± 5.81
		(n=8)	(n=8)	(n=8)	(n=6)	(n=4)	(n=3)	(n=1)
MCS	LSM, SE							
Dogs that lost weight		0.83 ± 0.08	0.82 ± 0.08	0.82 ± 0.08	0.77 ± 0.08	0.73 ± 0.08[a]	0.62 ± 0.08[a]	0.66 ± 0.09[a]
		(n=133)	(n=127)	(n=117)	(n=99)	(n=74)	(n=57)	(n=34)
Dogs that gained weight		1.12 ± 0.31	1.12 ± 0.31	1.12 ± 0.31	1.29 ± 0.32	1.38 ± 0.34	1.44 ± 0.35	1.20 ± 0.45
		(n=8)	(n=8)	(n=8)	(n=6)	(n=4)	(n=3)	(n=1)

BCS: body condition score, BFI: body fat index, MCS: muscle condition score, LSM: least squares means, SE: standard error, n: number of dogs for each data point. a indicates values significantly different from baseline.

Table 6. *Quality of life characteristics in dogs by week as measured for the dogs that lost weight or gained weight. Data is presented as least squares means and standard error. The number of animals included in each measurement is indicated in parenthesis.*

	Weeks of the study						
	0	**4**	**8**	**12**	**16**	**20**	**24**
Energy (scores 0- 10)							
Dogs that lost weight	5.75 ± 0.15	6.25 ± 0.15[a]	6.75 ± 0.16[a]	7.07 ± 0.16[a]	7.20 ± 0.17[a]	7.39 ± 0.18[a]	7.40 ± 0.20[a]
	(n=151)	(n=147)	(n=135)	(n=116)	(n=85)	(n=68)	(n=37)
Dogs that gained weight	8.07 ± 0.71	8.21 ± 0.72	8.07 ± 0.72	7.71 ± 0.79	8.13 ± 0.83	8.14 ± 0.83	
	(n=7)	(n=7)	(n=7)	(n=4)	(n=3)	(n=3)	
Happiness (scores 0 - 10)							
Dogs that lost weight	7.87 ± 0.13	8.07 ± 0.13[a]	8.22 ± 0.13[a]	8.25 ± 0.13[a]	8.32 ± 0.14[a]	8.41 ± 0.14[a]	8.50 ± 0.16[a]
	(n=151)	(n=147)	(n=135)	(n=115)	(n=85)	(n=68)	(n=37)
Dogs that gained weight	9.0 ± 0.60	9.14 ± 0.60	9.14 ± 0.06	9.15 ± 0.64	9.15 ± 0.67	9.15 ± 0.67	
	(n=7)	(n=7)	(n=7)	(n=4)	(n=3)	(n=3)	
Appetite (scores 0 - 10)							
Dogs that lost weight	8.39 ± 0.16	8.31 ± 0.16	8.18 ± 0.16	8.08 ± 0.16	8.29 ± 0.17	8.37 ± 0.18	8.27 ± 0.21
	(n=151)	(n=148)	(n=135)	(n=115)	(n=85)	(n=67)	(n=37)
Dogs that gained weight	7.57 ± 0.74	8.00 ± 0.74	8.00 ± 0.74	8.14 ± 0.81	8.17 ± 0.85	8.17 ± 0.85	
	(n=7)	(n=7)	(n=7)	(n=4)	(n=3)	(n=3)	
Begging (scores 0 - 10)							
Dogs that lost weight	6.85 ± 0.22	6.72 ± 0.22	6.55 ± 0.22	6.56 ± 0.22	6.61 ± 0.23	6.69 ± 0.24	6.67 ± 1.12
	(n=150)	(n=147)	(n=134)	(n=114)	(n=85)	(n=67)	(n=37)
Dogs that gained weight	6.71 ± 1.02	6.71 ± 1.02	6.86 ± 1.02	6.98 ± 1.08	7.01 ± 1.12	7.01 ± 1.12	
	(n=7)	(n=7)	(n=7)	(n=4)	(n=3)	(n=3)	
Flatulence (scores 0 - 10)							
Dogs that lost weight	2.77 ± 0.21	2.38 ± 0.21	2.05 ± 0.21	1.86 ± 0.22	1.93 ± 0.23	2.00 ± 0.24	2.10 ± 0.27
	(n=151)	(n=147)	(n=135)	(n=114)	(n=84)	(n=66)	(n=37)
Dogs that gained weight	1.71 ± 0.98	1.86 ± 0.98	2.00 ± 0.99	1.80 ± 1.06	1.79 ± 1.12	1.45 ± 1.12	
	(n=7)	(n=7)	(n=7)	(n=4)	(n=3)	(n=3)	
Stool volume (scores 0 -10)							
Dogs that lost weight	5.34 ± 0.14	5.61 ± 0.14	5.57 ± 0.14	5.62 ± 0.14	5.64 ± 0.15	5.60 ± 0.16	5.75 ± 0.76
	(n=150)	(n=146)	(n=134)	(n=114)	(n=85)	(n=67)	(n=37)
Dogs that gained weight	4.86 ± 0.64	5.14 ± 0.64	5.43 ± 0.64	5.40 ± 0.71	5.50 ± 0.76	5.50 ± 0.76	
	(n=7)	(n=7)	(n=7)	(n=4)	(n=3)	(n=3)	
Fecal score (1-5)							
Dogs that lost weight	3.68 ± 0.08	3.82 ± 0.08	3.89 ± 0.08	3.86 ± 0.08	3.86 ± 0.08	3.91 ± 0.09	3.96 ± 0.10
	(n=147)	(n=143)	(n=130)	(n=110)	(n=82)	(n=65)	(n=36)
Dogs that gained weight	3.28 ± 0.36	3.28 ± 0.36	3.28 ± 0.36	3.32 ± 0.39	3.32 ± 0.40	3.32 ± 0.40	
	(n=7)	(n=7)	(n=7)	(n=4)	(n=3)	(n=3)	

[a] *indicates values significantly different from baseline.*

factors related to: 1) dog signalment 2) food selection and dietary compliance 3) general activity levels of dogs.

Firstly, our study evaluated client-owned dogs under real household conditions as opposed to colony dogs, which meant that dogs of diverse breeds, sexes, and ages were enrolled. Different dog breeds might have variable responses in regard to weight loss regimens. For example, Labrador retrievers (which were the predominant breed in this study) have been shown to need greater energy restrictions to achieve weight loss.[22] There was also a high proportion of females and more specifically neutered females in our study compared to males, which could also account for a slower weight loss rate.[7,23] For instance, one study showed that female dogs require more caloric restrictions than male dogs to achieve weight loss.[24]

Finally, the age of dogs enrolled in the study ranged from 1 to 15 years of age, which can also affect degree of caloric restriction needed to achieve weight loss. Secondly, feeding regimens in clinical studies are less controlled than in experimental setting, and owner compliance in regard to amount of food fed and feeding of additional treats is highly variable.

Our results, with regard to overall weight loss after 24 weeks were lower than those obtained in a previous experimental trial of the same food fed to beagles.[9] The dogs in our study lost approximately 14.5% of their initial BW over a 24-week period, whereas experimental dogs lost 20-25% of their initial BW over a 16-week period when being fed the same type of diet.[9,13] Research colony dogs typically have higher energy requirements when compared to pet dogs, which likely enhances weight loss rates reported in experimental studies. However, our results are close to those of a short duration (2 months) in-home weight loss study which included 159 overweight/obese dogs. Dogs in this study achieved a weight loss rate of 0.8% initial BW per week while being fed the NWMF.[13]

Thirdly, the current study was focused on inducing weight loss through dietary changes only, and although dog owners were advised to increase their pets exercise level, no specific recommendations or guidelines were established in regard to an exercise program. Exercise and activity levels of enrolled dogs were therefore variable.

Approximately 40% of the dogs achieved their target weight and did so over approximately 2.5 months. This percentage would likely have been higher had the duration of the study been longer, particularly since dogs that achieved IBW had a lower starting BCS than those that did not. Approximately three fourth of the dogs achieved IBW before their last examination as part of the study, and all of these dogs maintained IBW until the end of the study period. These results confirm that feeding NWMF led to successful weight maintenance without the need to transition to a new food. However, a study with a longer follow-up duration is needed to confirm the effectiveness of long-term weight maintenance using NWMF.

The average BCS at the beginning of the study was close to 4.5, which reflects that a number of the dogs enrolled in the study were not only overweight, but obese (~30% excess BW).[25] The average BCS at the end of the study was 3.6, which is still considered overweight, but shows a general improvement by at least 1 score.

BCS as an indicator for weight loss is considered less sensitive than body weight.[26] The mean percentage of weight loss (in dogs that lost weight) from the beginning to the end of the study was 14.5%, which corresponded to a 1 point decrease in BCS on a 5-point scale in our study. Some investigators have shown that each point above 3 on a 5-point scale corresponded to 10% of body weight above the target BCS of 3/5, while other studies suggest that each point above 5 on a 9-point scale more closely equates to a 10% change of starting weight per unit of BCS.[25,27-29] Discrepancies between the observed and expected change in BCS in relation to lost body weight in our study might be related to inconsistencies in the attribu-

tion of scores since a number of different evaluators were responsible for scoring the body condition of enrolled dogs.

The BFI decreased by approximately 12% in the group of dogs that lost weight, which corresponded to a drop from 43% BFI at the beginning of the study to 31% at the end of the study. According to the Hill's BFI risk chart, this corresponded to a decrease from moderate to mild risk of obesity.[16] Our study used the Hill's BFI risk chart to estimate IBW. This choice, rather than using BCS, was made based on recent findings that showed that current BCS systems may overestimate IBW and caloric needs for weight loss in dogs with a BFI greater than 45%.[30]

The MCS in our study only decreased significantly towards the end of the study but the overall change from the beginning to the end of the study was only 0.2. Obese individuals have enlarged muscle mass, and some muscle mass loss is a component of every weight loss plan. It is estimated that of each kg of weight lost, about 25% corresponds to a loss in muscle mass, while the other 75% represents a loss of body fat.[31] Our results thus confirmed that dogs lost weight while on the NWMF diet without losing critical muscle mass.

Owners of dogs that lost weight perceived a significant increase in energy and happiness in their pets. Neither appetite nor begging scores changed significantly over time. There was a slight decrease in flatulence scores and a slight increase in stool volume and consistency scores in dogs that lost weight. The NWMF formulation is a high-fiber diet and is expected to result in larger stool volumes as compared to a low-fiber maintenance food. Questionnaires for the assessment of quality of life in dogs were only developed in recent years and, to our knowledge, were only used in one published study to evaluate weight loss related changes.[32-35] German et a. reported an increase in vitality in dogs that completed a weight loss program.[35] The questionnaire and scoring system used in our study was not validated, but mostly served the pur-

pose to see if dietary changes positively or negatively impacted certain criteria in the dogs' lives.

The goal of this study was to evaluate the effectiveness of the NWMF to induce weight loss and maintenance under real household conditions without a strict control of the amount of additional treats or foods offered to the participating dogs. Even though there were no specific restrictions in regard to additional foods, the majority of dogs enrolled in the study still lost weight. Similarly, results of our study showed that weight loss and weight maintenance were achieved, even though a number of dogs were not under strict caloric control and consumed more than the recommended amount of food. Despite these less controlled conditions, the weight loss rates in our study were comparable to those of a rigorously managed program using a typical dietetic weight loss food, where dogs lost an average of 0.8% of body weight per week.[6]

In a previous study, evaluating weight loss in a research colony of overweight/obese dogs fed NWMF, modified gene expression was shown in dogs undergoing weight loss.[9] It would be expected that caloric restriction decreases metabolic rate, which lowers the amount of calories needed to maintain the new weight. Successful weight loss in the dogs in our study, despite of a higher than recommended food intake, might indicate that the nutritional formulation used in NWMF prevented the decrease in energy expenditure of dogs as a result of weight loss. This possible nutrigenomic effect would maintain weight loss rate despite of an increased caloric intake. Negative consequences of dietary energy restriction on energy expenditure were addressed in a recent report on colony dogs. Obese dogs fed NWMF for weight loss (4 months) and weight maintenance (4 months) consumed 25% and 33.7% more calories per kg IBW in months 7 and 8, respectively, compared to their adiposity matched controls fed a variety of foods for maintenance of obese weight.[36] Results of this nutrition trial support that metabolic rate after the weight loss

phase appeared to increase as evidenced by the preservation of body weight despite the increased caloric intake compared to a control group. However, more studies are needed to evaluate metabolic rate via indirect calorimetry to confirm this potential biological effect.

The present study had a number of limitations. Firstly, it was an observational, uncontrolled, unmasked clinical trial, and bias in regard to the effectiveness of the NWMF can, therefore, not be excluded. However, the large number of dogs enrolled in the study and the variety of veterinary clinics that participated in the study, likely reduced this effect and strengthens the validity of our findings. This study evaluated the effectiveness of the NWMF to achieve weight loss in obese/overweight client owned dogs.

In order to compare its effectiveness to that of other foods or to that of combined diet/exercise weight loss strategies, a randomized, controlled, blinded clinical trial would be indicated.

Secondly, there were variations in the assessment of weight-loss related parameters. BW was measured by using different scales (different brands, calibration, precision) to weigh animals, which reduced the precision of this measurement and scores for BCS, BFI, MCS were attributed by a number of different veterinarians without evaluation of intra- or inter- observer differences. Nevertheless, these conditions reflected what is routinely encountered in clinical practice and can, therefore, be considered acceptable for the purpose of our study.

Thirdly, as mentioned previously, quality of life questionnaires were not validated, but gave a general idea of what the owner perceived as positive or negative effects of the food on their dogs.

Fourthly, not all dogs included in the present study completed the study. This situation is also reflective of conditions in clinical practice. We decided to maintain a number of data points from dogs in the study rather than only maintaining those that participated from beginning to end in order

to gain insight into the effectiveness of the NWMF in clinical practice rather than its efficacy.

In conclusion, this clinical study confirmed the effectiveness of the NWMF in achieving weight loss and maintenance in overweight/obese client-owned dogs in spite of a higher than recommended caloric intake. Owners reported significant improvements in dog's quality of life, specifically in regard to perceived levels of energy and happiness, without negative side effects such as increases in appetite or begging behavior. NWMF is the first food for both weight loss and weight maintenance and may improve compliance and success in managing this frustrating disease.

FOOTNOTES

[a]http://www.petobesityprevention.org/2012-national-pet-obesity-survey-results/

[b] Hill's™ Prescription Diet™ Canine Metabolic Advanced Weight Solution, dry, Hill's Pet Nutrition Manufacturing s.r.o., Hustopece, Czech Republic.

[c] http://www.hillsvet.co.uk/

[d] SAS version 9.3., SAS Institute Inc., Cary, NC, USA

CONFLICT OF INTEREST STATEMENT

The study was sponsored by Hill's Pet Nutrition and Drs Bečvářová and Meyer are employees of Hill's Pet Nutrition. Drs Christmann and Werre received financial compensation as consultants on behalf of Hill's Pet Nutrition for their involvement in this study. The food for the study was donated by Hill's Pet Nutrition.

REFERENCES

1. Lund E, Armstrong P, Kirk C. Prevalence and risk factors for obesity in adult dogs from private US veterinary practices. *International Journal of Applied Research in Veterinary Medicine* 2006;4:177-186.
2. Brooks D, Churchill J, Fein K, et al. 2014 AAHA weight management guidelines for dogs and cats. *J Am Anim Hosp Asso*c 2014;50:1-11.
3. German AJ. The growing problem of obesity in dogs and cats. *J Nutr* 2006;136:1940S-1946S.
4. Courcier EA, Thomson RM, Mellor DJ, et al. An epidemiological study of environmental factors associated with canine obesity. *J Small Anim Pract* 2010;51:362-367.
5. Kealy RD, Lawler DF, Ballam JM, et al. Effects of

diet restriction on life span and age-related changes in dogs. *J Am Vet Med Assoc* 2002;220:1315-1320.

6. German AJ, Holden SL, Morris PJ, et al. Long-term follow-up after weight management in obese dogs: the role of diet in preventing regain. *Vet J* 2012;192:65-70.

7. German AJ, Holden SL, Bissot T, et al. Dietary energy restriction and successful weight loss in obese client-owned dogs. *J Vet Intern Med* 2007;21:1174-1180.

8. Saker KE, Remillard RL. Performance of a canine weight-loss program in clinical practice. *Vet Ther* 2005;6:291-302.

9. Hahn KA, Meyer H. The nutrigenomics story: opening avenues to help solve obesity in dogs and cats. Hill's Global Symposium on Obesity 2013;22-23.

10. Yamka RM, Friesen KG, Gao X, et al. Identification of genes related to obesity in dogs. *FASEB J Supplement* A4 2007:28.24.

11. Yamka RM, Frantz NZ, Al-Murrani S. Pet food compositions and methods for weight loss and maintenance: Google Patents, 2012.

12. Hahn KA, Meyer H. Evidence-based nutrition for obesity management and weight gain prevention. . Hill's Global Symposium on Obesity 2013;26-28.

13. Hahn KA, Becvarova I, Towell T. The proof of a weight management food is in the eating of it, at home. Hill's Global Symposium on Obesity 2013;29-30.

14. Freeman L, Becvarova I, et al WSAVA Nutritional Assessment Guidelines. *J Small Anim Pract* 2011;52:385-396.

15. Toll PW, Yamka RM, Schoenherr WD. Obesity In: Hand MS, Thatcher CD, Remillard RL, eds. *Small Animal Clinical Nutrition.* Topeka, Kansas: Mark Morris Institute, 2010;501-542.

16. Witzel AL, Kirk CA, Henry GA, et al. Use of a novel morphometric method and body fat index system for estimation of body composition in overweight and obese dogs. *J Am Vet Med Assoc* 2014;244:1279-1284.

17. Thatcher CD, Hand MS, Remillard RL. Small Animal Clinical Nutrition: An Iterative Process. *Small Animal Clinical Nutrition*. 5th ed: Mark Morris Institute, 2010;1-21.

18. Jergens AE, Schreiner CA, Frank DE, et al. A scoring index for disease activity in canine inflammatory bowel disease. *J Vet Intern Med* 2003;17:291-297.

19. Markwell PJ, Butterwick RF, Wills JM, et al. Clinical studies in the management of obesity in dogs and cats. *Int J Obes Relat Metab Disord* 1994;18 Suppl 1:S39-43.

20. Mlacnik E, Bockstahler BA, Muller M, et al. Effects of caloric restriction and a moderate or intense physiotherapy program for treatment of lameness in overweight dogs with osteoarthritis. *J Am Vet Med Assoc* 2006;229:1756-1760.

21. Yaissle JE, Holloway C, Buffington CA. Evaluation of owner education as a component of obesity treatment programs for dogs. *J Am Vet Med Assoc* 2004;224:1932-1935.

22. Bissot T, Servet E, Biourge V. Energy allowance to induce weight loss is affected by breed and sex but not diet. 10th Congress of the European Society of Veterinary and Comparative Nutrition 2006.

23. Colliard L, Ancel J, Benet J, et al. Risk factors for obesity in dogs in France. *J Nutr* 2006;136:1951-1954.

24. Diez M, Nguyen P, Jeusette I, et al. Weight loss in obese dogs: evaluation of a high-protein, low-carbohydrate diet. *J Nutr* 2002;132:1685S-1687S.

25. Toll PW, Yamka RM, Schoenherr WD, et al. Chapter 27: Obesity In: Hand MS, Thatcher CD, Remillard RL, eds. S*mall Animal Clinical Nutrition*. 5th ed. Topeka, Kansas: The Mark Morris Institute, 2010;501-542.

26. Dorsten CM, Cooper DM. Use of body condition scoring to manage body weight in dogs. *Contemp Top Lab Anim Sci* 2004;43:34-37.

27. Burkholder WJ, Toll PW. Obesity In: Hand MS, Thatcher CD, Remillard RL, et al., eds. *Small Animal Clinical Nutrition*. 3rd ed. Topeka: Mark Morris Institute, 2000;401-430.

28. German AJ, Holden SL, Bissot T, et al. Use of starting condition score to estimate changes in body weight and composition during weight loss in obese dogs. *Res Vet Sci* 2009;87:249-254.

29. Laflamme DE. Development of a body condition score system for dogs. *Canine practice* 1997;22:5-10.

30. Lusby AL, Kirk CA, Toll PW, et al. Effectiveness of body condition scoring for estimation of ideal body weight and energy requirements in overweight and obese dogs compared to DXA. American College of Veterinary Internal Medicine Forum 2010.

31. Chan DL, Freeman LM. Nutrition in critical illness. *Vet Clin North Am Small Anim Pract* 2006;36:1225-1241, v-vi.

32. Reid J, Wiseman-Orr ML, Scott EM, et al. Development, validation and reliability of a web-based questionnaire to measure health-related quality of life in dogs. *J Small Anim Pract* 2013;54:227-233.

33. Wiseman-Orr ML, Scott EM, Reid J, et al. Validation of a structured questionnaire as an instrument to measure chronic pain in dogs on the basis of effects on health-related quality of life. *Am J Vet Res* 2006;67:1826-1836.

34. Wiseman-Orr ML, Nolan AM, Reid J, et al. Development of a questionnaire to measure the effects of chronic pain on health-related quality of life in dogs. *Am J Vet Res* 2004;65:1077-1084.

35. German AJ, Holden SL, Wiseman-Orr ML, et al. Quality of life is reduced in obese dogs but improves after successful weight loss. *Vet J* 2012;192:428-434.

36. Jewell D, Floerchinger A, Jackson M. A reduced calorie, high fiber food with added coconut oil, l-carnitine, lysine, and leucine increases basal metabolic rate in overweight and obese dogs. *J Vet Intern Med* 2014;28:1087-1088..