The Effect of Diet and Lysine:Calorie Ratio on Body Composition and Kidney Health in Geriatric Cats

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ABSTRACT

Study 1: A study was conducted to determine the effects of geriatric foods utilizing 40 healthy geriatric cats (≥12 years, initially 4.6 kg). Cats were fed a control food during a 30-day pre-feeding period, blocked by age, gender, and body fat percentage, and randomly assigned to 1 of 4 foods (A = experimental geriatric food, B = Iams Active Maturity, C = Royal Canin Mature 28, and D = Purina ONE Senior Protection Formula) for the 90-day testing period. Chemistry screens and microalbuminuria were evaluated at Day 30 and Day 90 along with dual-energy x-ray absorptiometry (DEXA) scan at Day 90. Cats fed all foods maintained weight and body fat content throughout the study. At Day 90, cats fed food D had reduced ($P < 0.01$) bone mineral content. Cats fed food A and C had reduced ($P < 0.03$) lean. Cats fed food A tended to have a lower percentage of cats with renal damage ($P < 0.08$) compared with cats fed food B. For vital organ measures, cats fed food A had lower ($P < 0.03$) blood urea nitrogen (BUN) levels compared with cats fed food D. Cats fed food A had lower ($P < 0.01$) creatinine compared with cats fed food B.

Study 2: A second trial was conducted to evaluate the effect of altering the lysine: calorie ratio in feline geriatric foods utilizing 36 healthy geriatric cats (≥12 years, initially 4.7 kg). Cats were blocked by age, gender, and body fat and assigned to 1 of 4 foods (E = Purina ONE Senior Protection Formula, F = experimental geriatric food, G = experimental geriatric food + lysine, and H = experimental geriatric food + lysine with lower L-carnitine) for the 90-day feeding period. Chemistry screens, DEXA scans, and microalbuminuria were evaluated after 3 months. Body weight, fat, lean, and bone mineral content changes over time were unaffected by dietary treatment ($P > 0.15$). However, cats fed food H weighed less and had less fat ($P < 0.03$) compared with cats fed food E. Cats fed food F also had less fat ($P < 0.05$) than cats fed food E. Blood urea nitrogen, creatinine, BUN:creatinine ratio, and the percentage of animals with renal damage were unaffected by dietary treatment ($P > 0.35$). By combining the data from both studies and plotting increasing lysine:calorie ratio versus lean loss for each corresponding ratio, a strong linear relationship could be detected with the line representing 75% ($R^2 = 0.75$) of the variation in lean loss. A moderate linear relationship was detected as bone mineral content decreased with increasing crude protein concentration ($R^2 = 0.24$). These studies suggest that feeding a food with reduced protein/phosphorus and higher levels of polyunsaturated fatty acids as well as antioxidants improved markers of kidney function compared with other commercial formulas. Additionally,

increasing the lysine:calorie ratio prevented the loss of lean body mass in the geriatric cat and provided a similar response to high protein foods.

INTRODUCTION

Increased dietary protein intake has been implicated in foods designed for weight management in various animal species as part of a reduced caloric food.[1,2] Inadequate protein or amino acid availability results in muscle loss, impaired immune system, and poor hair coat quality.[3] However, high dietary protein intake is associated with increased risk of kidney disease,[4,5] increased bone loss,[6] and may increase formation of calcium oxalate crystals[7] in cats. Increasing protein concentration in foods for weight loss, lean maintenance, and improved insulin sensitivity may put the animal at risk for other diseases related to excess nitrogen metabolism or mobilization of calcium.

Balancing foods based on total protein will over formulate the food for some essential and non-essential amino acids. Lysine is required for protein deposition or maintenance of muscle mass[8] with the requirements of the other essential amino acids often expressed relative to dietary lysine concentration.[9] Because of the relationship between energy and protein on body composition, increasing the lysine:calorie ratio, and thus the other essential amino acids relative to lysine rather than total protein in foods, may provide an alternative means to maintain lean muscle mass in weight management or geriatric foods without negative implications of excess protein on other health indices.

Thus, the objective of these studies was to determine the effect of 3 commercially available foods and 1 experimental geriatric food with various protein levels or the effect of enhanced lysine:calorie ratio on quality of life in geriatric cats as determined by measures of body composition and kidney health.

MATERIALS AND METHODS

Animal Care and Health

Prior to the studies, cats were determined to be healthy by physical exam and blood chemistry screen. Cats with confirmed renal failure, cancer, arthritis, hyperthyroidism, or other diseases were excluded from these studies. The cats were located in the Hill's Pet Nutrition Center (Topeka, KS) and cared for in accordance with Institutional Animal Care and Use Committee protocols. Additionally, cats were offered enrichment toys, received routine grooming, and had daily opportunities for socialization with other cats and people.

Study 1

Forty healthy geriatric cats were fed a control geriatric food during a 30-day prefeeding period, and then blood samples and dual-energy x-ray absorptiometry (DEXA; DXA-QDR-4500, Hologic, Inc., Waltham, Mass) scans were performed. The cats were blocked by age, gender, and body fat percentage and randomly assigned to 1 of 3 commercially available geriatric foods or the experimental geriatric food for the 90-day testing period. The 4 foods were (A-D): food A (experimental geriatric food), food B (Iams Active Maturity), food C (Royal Canin Mature 28), or food D (Purina ONE Senior Protection Formula) (Table 1). All foods were formulated to meet or exceed Association of American Feed Control Officials[10] nutrient recommendations. Animals were weighed weekly and food intake monitored daily.

Study 2

Thirty-six healthy geriatric cats were blocked by age, gender, and body fat percentage and randomly assigned to 1 of 4 food treatments. Cats were fed 1 of 4 foods (E-H): food E (Purina ONE Senior Protection), food F (experimental geriatric food), food G (experimental geriatric food + lysine), or food H (experimental geriatric food + lysine with lower L-carnitine) (Table

Table 1. Analyzed Nutrient Composition of the 4 Geriatric Foods (Study 1).

Nutrient, 100% Dry Matter Basis	Control[a]	Food A[b]	Food B[c]	Food C[d]	Food D[e]
Crude protein, %	34.62	34.30	32.16	28.37	37.23
Fat, %	28.53	21.57	15.39	21.97	14.69
Crude fiber, %	2.50	2.80	1.88	1.05	2.20
Ca, %	0.95	0.94	1.12	0.75	1.16
P, %	0.71	0.77	0.97	0.67	1.17
Ash, %	5.31	5.36	6.22	5.34	6.73
Sodium, %	0.25	0.27	0.44	0.41	0.46
Potassium, %	0.85	0.72	0.82	0.60	0.73
Magnesium, %	0.07	0.08	0.10	0.18	0.12
Chloride, %	0.81	0.69	0.77	0.41	0.53
DHA, %	<0.01	0.23	0.08	0.11	0.07
EPA, %	<0.01	0.32	0.06	0.13	0.06
Linoleic acid, %	3.9	5.05	2.52	4.78	1.92
Total n-3 fatty acids, %	0.26	1.14	0.26	0.74	0.29
Total n-6 fatty acids, %	3.99	5.09	2.65	5.02	1.96
Taurine, ppm	1900	2100	1800	1600	2100
Carnitine, ppm	20	367	26	90	23
Lysine, %	1.53	1.51	2.12	1.12	1.84
Arginine, %	1.83	1.75	2.02	1.46	2.24
Methionine, %	.84	1.32	0.97	0.67	0.71
Cysteine, %	.43	0.47	0.36	0.47	0.53
Threonine, %	1.27	1.28	1.32	1.08	1.46
Tryptophan, %	0.31	0.26	0.33	0.23	0.33
Leucine, %	3.79	3.72	2.57	3.10	3.76
Valine, %	1.63	1.54	1.55	1.47	1.81
Isoleucine, %	1.36	1.26	1.29	1.20	1.53
Manganese, ppm	19	104	58	65	65
Vitamin E, IU/kg	96	1241	362	540	888
Vitamin C, ppm	23	135	11	390	101
Atwater metabolizable energy, kcal/kg	4507	4154	3776	4130	3642
Lysine:calorie ratio	3.39	3.64	5.72	2.71	5.05

[a]Control food ingredient list: poultry meal, corn gluten meal, rice, corn meal, animal fat, soy mill run, pal enhancer, cellulose, potassium chloride, choline chloride, calcium carbonate, calcium sulfate, DL-methionine, yeast, salt, potassium citrate, taurine, preservative, vitamin premix, mineral premix, and arginine.

[b]Experimental geriatric food ingredient list: corn meal, poultry meal, corn gluten meal, animal fat, soybean mill run, soybean oil, beet pulp, fish oil, pal enhancer, calcium sulfate, potassium chloride, DL-methionine, choline chloride, L-carnitine, vitamin E, yeast, potassium citrate, vitamin premix, L-lysine, taurine, iodized salt, L-cysteine, mineral premix, L-threonine, and manganese sulfate.

[c]Iams Active Maturity.

[d]Royal Canin Mature 28.

[e]Purina ONE Senior Protection Formula.

Table 2. Analyzed Nutrient Composition of 4 Geriatric Foods (Study 2).

Nutrient, 100% Dry matter basis	Food E[a]	Food F[b]	Food G[c]	Food H[d]
Protein, %	45.2	36.1	36.1	37.7
Fat, %	17.5	22.0	21.8	22.5
Crude fiber, %	0.9	2.7	2.7	2.7
Calcium, %	1.86	0.98	0.88	0.93
Phosphorus, %	1.56	0.80	0.75	0.77
Ca:P	1.20	1.20	1.20	1.20
Sodium, %	0.59	0.28	0.26	0.29
Potassium, %	0.91	0.85	0.83	0.83
Magnesium, %	0.13	0.09	0.08	0.08
Chloride, %	0.88	0.73	0.99	0.89
Manganese, ppm	86	110	112	104
Lysine, %	2.04	1.65	2.75	2.68
Methionine + cysteine, %	1.41	1.87	1.81	1.94
Tryptophan, %	0.41	0.27	0.25	0.28
Threonine, %	1.58	1.26	1.20	1.26
Arginine, %	2.64	1.84	1.75	1.86
Isoleucine, %	1.84	1.32	1.29	1.39
Valine, %	2.23	1.62	1.60	1.67
Leucine, %	4.34	3.88	3.91	4.23
Histidine, %	1.02	0.72	0.72	0.77
Phenylalanine + tyrosine, %	3.63	2.92	2.89	3.09
Carnitine, ppm	31	564	571	62
Atwater metabolizable energy, kcal/kg	4658	4364	4362	4406
Lysine:calorie	4.38	3.78	6.30	6.08

[a]Purina ONE Senior Protection Formula.

[b]Experimental geriatric food ingredient list: corn meal, poultry meal, corn gluten meal, animal fat, soybean mill run, soybean oil, beet pulp, fish oil, pal enhancer, calcium sulfate, potassium chloride, DL-methionine, choline chloride, L-carnitine, vitamin E, yeast, potassium citrate, vitamin premix, L-lysine, taurine, iodized salt, L-cysteine, mineral premix, L-threonine, and manganese sulfate.

[c]Experimental geriatric food + lysine.

[d]Experimental geriatric food + lysine with lower L-carnitine.

2). All foods were formulated to meet or exceed AAFCO nutrient recommendations.[10] Animals were weighed weekly and food intake monitored daily.

Serum and Urine Analysis

Blood and urine samples were taken at 1, 2, and 4 months in Study 1, and at 3 months in Study 2. Collected serum was stored at -20°C in 1-mL aliquots. Serum was analyzed for chemistry screens and vital organ markers at the Hill's Pet Nutrition Center (Topeka, KS). Urine was sampled and microalbuminuria (Heska ERD kit) analysis conducted.

Statistical Analysis

The statistical analysis is the same as previously published.[11] Data were analyzed using General Linear Models procedure of SAS[12] to determine treatment means. The experimental unit was cat and Day 0 was used as a covariate. In Study 1, 5 geriatric foods were compared (A-D) and in Study 2, 4 geriatric foods were compared (E-H). Differences were considered significant when $P < 0.05$ and trends were determined when $P \leq 0.10$.

RESULTS

Study 1

Vital organ health. At Day 30, cats fed food A had lower (Table 3, $P < 0.01$) blood urea nitrogen (BUN) and lower ($P < 0.05$) BUN:creatinine compared with cats fed food D. At Day 90, cats fed food B tended to have lower ($P < 0.06$) BUN:creatinine compared with cats fed food A. Cats fed food A had lower ($P < 0.01$) BUN compared with cats fed food D. Creatinine levels were lower ($P < 0.05$) in cats fed food A compared with cats fed foods B or D.

Body composition. Cats fed all foods maintained weight and body fat content throughout the study. At Day 90, cats fed food A and C lost (Table 4, $P < 0.03$) lean. Furthermore, cats fed food A tended ($P < 0.10$) to weigh less and have less lean compared with cats fed food B. Cats fed food D had reduced ($P < 0.01$) bone mineral content.

Kidney health. The results of microalbuminuria analysis showed that at Day 30, cats fed food A had a lower percentage of cats with renal damage ($P < 0.04$) when compared with cats fed food B. Furthermore,

Table 3. Vital Organ Markers Measured in Blood in Cats at Day 30 and Day 90 (Study 1).

						Probability, *P* <			
Metabolite	Food A	Food B	Food C	Food D	SE	Treatment	Food A vs Food B*	Food A vs Food C*	Food A vs Food D*
BUN:creatinine									
Day 30	19.60	19.18	19.15	29.27	3.251	0.08	0.93	0.92	0.05
Day 90	20.03	17.46	19.74	21.78	0.969	0.02	0.06	0.83	0.21
BUN, mg/dL									
Day 30	20.94	22.61	19.86	26.13	1.130	0.01	0.29	0.50	<0.01
Day 90	22.23	25.08	23.02	29.39	1.361	0.01	0.12	0.67	<0.01
Creatinine, mg/dL									
Day 30	1.07	1.18	1.08	1.03	0.060	0.37	0.21	0.84	0.66
Day 90	1.15	1.41	1.24	1.31	0.060	0.02	<0.01	0.26	0.05

BUN = blood urea nitrogen.

*Probability of greater F-value.

cats fed food A tended ($P < 0.08$) to have a lower percentage of cats with renal damage compared with cats fed foods C and D. At Day 90, cats fed food A tended ($P < 0.08$) to have a lower percentage of cats with renal damage compared with cats fed food B (Table 5).

Study 2

Vital organ health. BUN, creatinine, and the BUN:creatinine ratio were unaffected by dietary treatment (Table 6, $P > 0.50$).

Body composition. Cats fed all 4 foods maintained weight, lean, fat, and bone mineral content (Table 7, $P > 0.15$) throughout

Table 4. Body Composition Measured in Geriatric Cats Fed 4 Foods (Study 1).

Body Parameter Measured	Food A	Food B	Food C	Food D	SE	Probability, P <			
						Treatment	Food A vs Food B*	Food A vs Food C*	Food A vs Food D*
Weight									
Day 0, kg	4.44	4.84	4.64	4.77	0.267	0.73	0.30	0.60	0.39
Day 90, kg	4.32	5.01	4.42	4.75	0.305	0.34	0.10	0.81	0.31
Change Day 0 to 90, kg	-0.12	0.17	-0.07	-0.02	0.138	0.44	0.13	0.78	0.59
Day 0 vs Day 90*	0.36	0.20	0.63	0.88			—	—	—
Lean									
Day 0, g	3408	3557	3183	3480	193.6	0.74	0.57	0.40	0.78
Day 90, g	3176	3634	3012	3472	190.3	0.09	0.08	0.54	0.25
Change Day 0 to 90, g	-232	77	-170	-8	72.9	0.01	0.04	0.82	0.20
Day 0 vs Day 90*	<0.01	0.27	0.03	0.91			—	—	—
Fat									
Day 0, g	1118	1380	1367	1326	156.6	0.49	0.22	0.26	0.33
Day 90, g	1173	1410	1459	1279	185.2	0.67	0.35	0.27	0.67
Change Day 0 to 90, g	54	30	92	-47	99.6	0.77	0.86	0.78	0.45
Day 0 vs Day 90*	0.56	0.75	0.36	0.62			—	—	—
Bone mineral content									
Day 0, g	121.1	132.3	117.9	131.4	8.56	0.76	0.34	0.79	0.38
Day 90, g	118.2	130.4	116.8	126.9	8.73	0.61	0.31	0.91	0.47
Change Day 0 to 90, g	-2.9	-1.9	-1.1	-4.5	1.85	0.57	0.70	0.49	0.51
Day 0 vs Day 90*	0.53	0.30	0.57	0.02			—	—	—

*Probability of greater F-value.

Table 5. Percentage of Cats Without Kidney Damage Measured by Urine Microalbuminuria in Cats (Study 1).

% Without Damage	Food A	Food B	Food C	Food D	Probability, *P* < Food A vs Food B*	Food A vs Food C*	Food A vs Food D*
Study 1							
Day 0, %	100	80	80	80	0.17	0.17	0.17
Day 30, %	100	60	70	70	0.04	0.08	0.08
Day 90, %	90	60	80	80	0.08	0.34	0.34

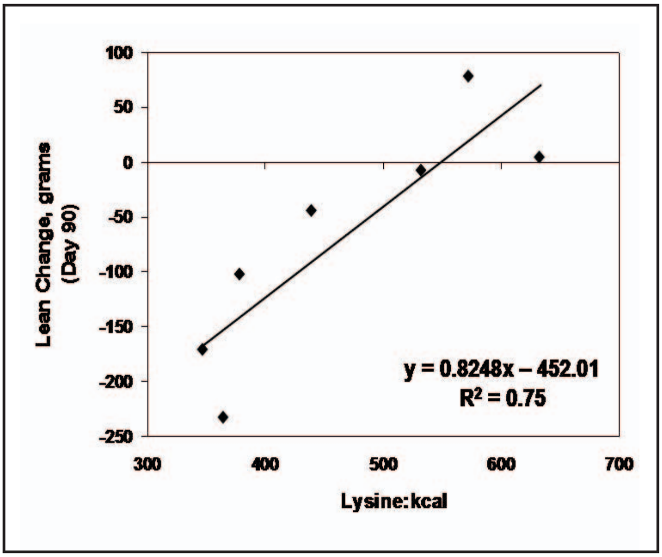
*Probability of a greater F-value compared to Food A.

Table 6. Vital Organ Markers Measured in Blood of Cats at Day 90 (Study 2).

Metabolite	Food E	Food F	Food G	Food H	SE	Probability, *P* < Treatment	Food E vs Food F*	Food E vs Food G*	Food E vs Food H*
BUN:creatinine	21.4	19.2	20.2	20.3	1.25	0.60	0.18	0.47	0.53
BUN, mg/dL	26.5	29.5	22.4	25.3	3.61	0.50	0.51	0.38	0.80
Creatinine, mg/dL	1.3	1.6	1.2	1.3	0.23	0.58	0.28	0.82	0.90

BUN = blood urea nitrogen.
*Probability of greater F-value.

Figure 1. Lysine:calorie ratio vs lean change at Day 90 (Study 1 and Study 2).



the study. However, cats fed food H weighed less and had less fat ($P < 0.03$) compared with cats fed food E. Cats fed food F also had less fat ($P < 0.05$) than cats fed food E.

Kidney health. There were no differences in the percentage of cats with renal damage among dietary treatments from microalbuminuria analysis (Table 8).

Study 1 and 2 Regression

By combining both studies and plotting the lysine:calorie ratio versus lean loss for each corresponding ratio, a strong linear relationship could be detected with the line representing 75% (Figure 1, $R^2 = 0.75$) of the variation in lean loss. As the lysine:calorie ratio increased, loss of lean muscle was reduced. In addition, a moderate linear relationship was detected as bone mineral content decreased with increasing crude protein concentration (Figure 2, $R^2 = 0.24$).

Table 7. Body Composition Measured in Geriatric Cats Fed 4 Foods (Study 2).

Parameter Measured	Food E	Food F	Food G	Food H	SE	Probability, *P* <			
						Treatment	Food E vs Food F*	Food E vs Food G*	Food E vs Food H*
Weight									
Day 0, kg	5.44	4.93	4.86	4.15	0.429	0.17	0.32	0.25	0.03
Day 90, kg	5.33	4.86	4.83	4.03	0.391	0.11	0.32	0.28	0.02
Change Day 0 to 90, kg	-0.11	-0.07	-0.03	-0.12	0.094	0.84	0.71	0.46	0.91
Day 0 vs Day 90*	0.15	0.40	0.72	0.20			—	—	—
Lean									
Day 0, g	3223	3375	3236	3284	228.0	0.94	0.57	0.96	0.84
Day 90, g	3145	3389	3250	3220	218.5	0.81	0.35	0.68	0.79
Change Day 0 to 90, g	-77	14	14	-64	71.1	0.58	0.28	0.28	0.88
Day 0 vs Day 90*	0.17	0.81	0.81	0.37			—	—	—
Fat									
Day 0, g	2078	1421	1496	758	297.0	0.02	0.07	0.10	0.01
Day 90, g	2047	1340	1453	699	295.2	0.02	0.05	0.10	0.01
Change Day 0 to 90, g	-31	-81	-43	-59	89.0	0.97	0.63	0.92	0.81
Day 0 vs Day 90*	0.65	0.28	0.58	0.51			—	—	—
Bone mineral content									
Day 0, g	134.0	132.3	123.3	109.8	11.46	0.37	0.90	0.43	0.11
Day 90, g	133.0	131.8	122.9	109.4	10.92	0.35	0.92	0.43	0.11

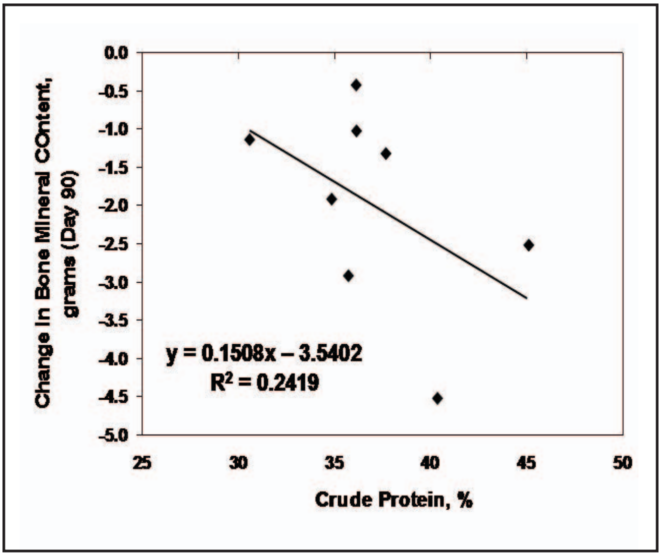
*Probability of greater F-value.

Table 8. Percentage of Cats Without Kidney Damage Measured by Urine Microalbuminuria in Cats (Study 2).

% Without Damage	Food E	Food F	Food G	Food H	Probability, *P* <		
					Food E vs Food F*	Food E vs Food G*	Food E vs Food H*
Study 2							
Day 0, %	100	77.8	77.8	88.8	0.17	0.17	0.35
Day 90, %	66.6	77.8	77.8	77.8	0.35	0.35	0.35

*Probability of a greater F-value compared to Food E.

Figure 2. Bone mineral content loss vs crude protein % at Day 90 (Study 1 and Study 2).



in preservation of muscle mass with all treatments maintaining weight and lean. Laflamme and Hannah[19] reported preservation of lean in cats during weight loss with increased dietary protein percentage. Additionally, non-obese cats fed a high protein diet compared with a moderate protein diet retained greater lean over a 6-month period.[20] Taylor et al[21] showed that maximal growth could be obtained in kittens by providing essential amino acids compared with a diet containing essential and dispensable amino acids. This data supports the concept that the availability of essential amino acids influences protein mass versus the total protein in the diet. The results of this study suggest that providing additional lysine and thus other essential amino acids relative to lysine through the use of higher quality protein sources or synthetic amino acids can provide similar maintenance of lean without increasing dietary protein concentrations.

Cats fed food D had higher BUN, creatinine, and BUN:creatinine ratio at various time points in the study while cats fed food B had higher creatinine at Day 90 suggesting reduced kidney function compared with cats fed food A.[22] In addition, at Day 30 and Day 90, microalbuminuria analysis showed that cats fed food B had a greater percentage of cats with renal damage compared with cats fed food A[23] while cats fed foods C and D tended to only at Day 30. Interestingly, the analyzed dietary protein concentration was slightly lower in food B compared with food A. Contrary to this, Adams et al[24] found that restricting dietary protein and calories resulted in improved measures of kidney function in cats with surgically induced chronic renal failure. Similarly, Jacob et al[25] demonstrated reduced rate of renal disease progression and reduced mortality rates in dogs fed a reduced protein diet compared with an

DISCUSSION

Decline in muscle mass and organ function with age are major concerns in geriatric animals. To counteract this, foods have been formulated to contain higher protein concentrations to limit lean muscle loss and prevent fat accumulation; however, excessive dietary protein or phosphorus can lead to renal disease[4,13] and formation of calcium oxalate stones.[7] Dietary management has become essential to limit the risk for kidney disease and support quality and length of life in geriatric pets.[14-16] The objective of these studies was to determine the effect of food and lysine:calorie ratio on body composition and kidney function in cats.

In the first study, cats fed food A and C had reduced lean at Day 90, which suggests that muscle was being lost over time. Although dietary protein was similar between treatments, the lysine:calorie ratio was lower in foods A and C compared with foods B and D. The lysine:calorie ratio is known to influence body composition in swine[17,18] and reflects the availability of essential amino acids to dietary energy density. Altering this ratio can dramatically influence body composition by influencing nitrogen retention and protein turnover. In the second study, increasing the lysine:calorie ratio resulted adult maintenance food. Polzin et al[26] also observed reduced serum urea nitrogen and mortality rates in dogs fed reduced protein foods (8% and 17% serum urea nitrogen, respectively) compared with a high protein food (44% serum urea nitrogen). In a human retrospective study, lowering protein intake was associated with a reduced death rate due to renal failure[27-29]; however, it did not find a relationship between protein intake and measures of kidney function in dogs. The poorer measures of kidney function observed may be a result of excess amino acids or increased dietary phosphorus, which has also been implicated in renal disease.[13,30] In the current study, dietary phosphorus was also lower in food A compared with foods B and D. Both Elliot et al[31] and Ross et al[32] reported that feeding a diet with reduced protein and phosphorus to cats with chronic renal failure increased survival time. Finco et al[33] attributed increased survival time to dogs fed a reduced phosphorus food compared with dogs fed a high phosphorus food. The combination of reduced protein and phosphorus may lead to prevention of further renal disease progression, improved signs of kidney function, and improve the quality of life in geriatric cats.

Other dietary factors may also play a critical role in the progression of renal disease. In the current study, dietary variation in polyunsaturated fatty acids, L-carnitine, and antioxidants may also contribute to the responses in kidney function measures. Brown et al[34] fed dogs different sources of polyunsaturated fatty acids and reported renal protective effects of omega-3 fatty acids. Plantinga et al[35] in a retrospective study evaluating commercially available diets for treatment of chronic renal disease in cats believed the most effective diet in increasing survival time contained a high concentration of eicosapentaenoic acid (EPA). Food A contained higher analyzed levels of the omega-3 fatty acid EPA than the other 3 commercial foods. Also, Aydogdu et al[36] demonstrated that L-carnitine had protective effects in an acute renal failure model with rats. L-carnitine was also provided in higher concentrations in food A compared with the other 3 commercial foods. Yu and Paetau-Robinson[37] showed a role for supplemental Vitamin C and E for reducing oxidative stress and DNA damage in cats with renal insufficiency. Providing additional nutrients such as these in addition to reduced protein and phosphorus foods may be beneficial on measures of kidney function and healthy aging.

Another side effect of high dietary protein may be the loss of bone mass. In the first study, cats fed food D had reduced bone mineral content at Day 90. By plotting the dietary protein concentration versus the change in bone mineral content, a moderate correlation was seen as increasing dietary protein increased loss of bone mineral content. High dietary protein may lead to increased calcium mobilization and excretion as a result of the bodies attempt to buffer the additional acid load.[38,39] Reddy et al[7] demonstrated that high protein diets increase acid load and urinary calcium excretion in humans. Even so, a positive role of high dietary protein on improving bone mineral density and reduced risk of hip fracture in the elderly has been reported from human trials.[40,41] Ammann et al[42] reported increased bone strength and bone mineral density in rats when fed a low-protein diet supplemented with essential amino acids and attributed this effect to observed increases in the insulin-like growth factor-1. The effect of protein on bone maintenance or loss is not well understood[43] and may further depend on the protein source or availability of essential amino acids supplied in the diet[37] along with interactions between other dietary factors.

CONCLUSION

In these studies, although the range of dietary protein concentrations was minimal, differences in measures of kidney function were affected by dietary treatment. This may indicate the importance of other dietary nutrients such as phosphorus, polyunsaturated fatty acids, and antioxidants in kidney health. In addition, increasing the lysine: calorie ratio maintained weight and lean muscle mass similar to high protein foods in the geriatric cat.

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