

Addressing Age-Related Changes in Feline Digestion

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Abstract

Body weight decline is widespread among cats older than 11 years. A large number of such cats do not show obvious signs of illness. Digestibility data from a large population of cats maintained in different colonies showed that approximately 30% of cats older than 11 years had an impaired ability to digest nutrients, more specifically fat and protein. There is a significant negative correlation between age and nutrient digestibility in senior cats. Decreased digestibility of nutrients over the long term may lead to negative energy and nitrogen balance. This may contribute to loss in body weight and lean body mass. Data also shows that reduction in digestibility may lead to a significant decline in circulating levels of critical nutrients such as vitamins E and B12. It is important to monitor body weight of senior cats. If weight loss is observed, it is critical to provide highly palatable, digestible, energy-dense food.

Introduction

Aging is defined as the progressive changes that occur after maturity in various organs, leading to a decrease in their functional ability.¹ Like humans, average life span of pets is increasing due to advances in medicine, nutrition and effective control of infectious diseases. Over the past 10 years there has been a 15% increase in cats over 10 years of age, and cats over 15 years of age have increased from 5 to 14%.² Gunn-Moore³ suggested four life stages in cats based on physical and metabolic changes occurring with age, beginning with young (birth to 1 year), progressing to adult (1 to 7 years), followed by maturity (7 to 11 years), and finally a senior or geriatric stage (>11 years). Therefore, in feeding cats, the nutritional goals are to slow or prevent the progression of metabolic changes associated with aging, enhance quality of life, and, if possible, increase life expectancy.

The objective of this presentation is to discuss age-related changes in nutrient digestion, specifically fat and protein digestibility and how these changes with aging may influence certain health measures. The health implications of reduced fat and protein digestibility in geriatric cats are discussed. A method for identifying cats with poor nutrient digestion in

Glossary of Abbreviations

AAFCO: Association of American Feed Control Officials
DEXA: Dual Energy X-Ray Absorptiometry
GI: Gastrointestinal
MER: Maintenance Energy Requirements
PLI: Pancreatic Lipase Immunoreactivity

clinical situations is suggested. Post-mortem data of cats that were identified as suffering from poor nutrient digestion are presented, and finally, potential strategies for dietary management of geriatric cats suffering from reduced digestive capacity are recommended.

Data Origin

The data presented are from Nestlé Purina PetCare (NPPC) cat colonies. NPPC cats are cared for with the objective that they are true representatives of the general cat population. Those that are not adopted into private homes are cared for during their entire natural lives in NPPC colonies. A home-like environment is provided, including regular play and interaction with humans and other cats. Development of social bonds with pet care personnel is encouraged. Health of the colony cats is maintained by in-house veterinarians with a focus on preventive medicine to ensure a healthy colony.

Nutrient Digestibility — Age

The nutrient digestibility data presented relates to apparent or total tract nutrient digestibility. Digestibility tests were performed using standard Association of American Feed Control Officials (AAFCO) digestibility protocol.

Fat digestibility in healthy adult cats in our colony averages 90 to 95%. Fat digestibility less than 80% is considered low, as it is more than two standard deviations below our colony average. Protein digestibility in healthy adult cats in our colony averages 85 to 90%. Protein digestibility less than 77% is considered low, as it is more than two standard deviations below our colony average. Fat or protein digestibility below 80% and 77%, respectively, may lead to significant negative health consequences over time.

Figure 1 shows historical fat digestibility data in cats with age ranging from 8 to 18 years. There was a significant ($P < 0.0001$) negative correlation ($r = -0.76$) between age and fat digestibility. The incidence of low fat digestibility increases with age, affecting approximately 10 to 15% of mature cats (8 to 12 years of age) and 30% of the geriatric cats (>12 years of age). In some geriatric cats, fat digestibility was found to be as low as 30% with large stools and low body weight as the only clinical signs.

Figure 1: Fat digestibility (%) of cats by age (n=208).

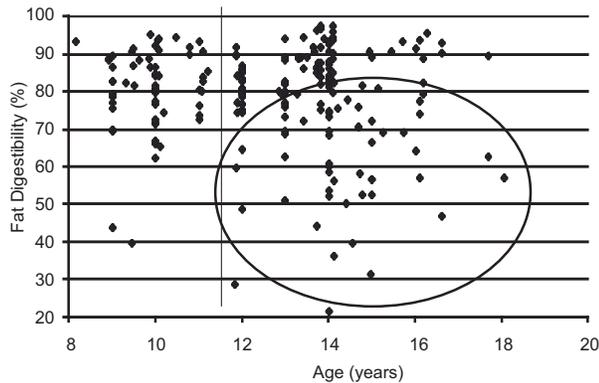


Figure 2: Protein digestibility (%) of cats by age (n=208).

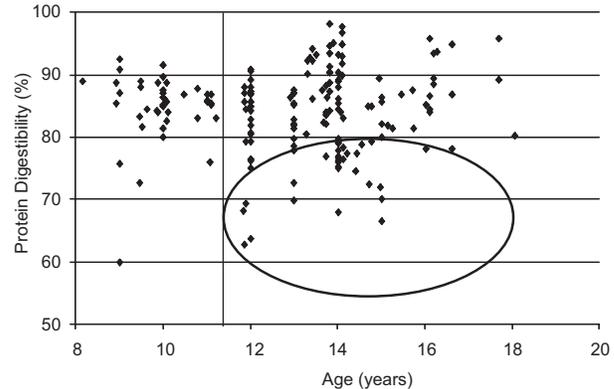


Figure 2 shows historical protein digestibility data in cats with age ranging from 8 to 18 years. There was a significant ($P < 0.0001$) negative ($r = -0.66$) correlation between age and protein digestibility. Low protein digestibility also seems to affect mature and geriatric cats. Although the incidence of low protein digestibility is not as high as low fat digestibility, approximately 20% of cats older than 14 years show protein digestibility lower than 77%. The incidence of low fat and protein digestibility tends to occur in the same cats.

Nutrient Digestibility and Age Across Multiple Colonies

Nutrient digestibility tests were conducted in 140 cats with age ranging from 8 to 18 years and given the same fish-based wet diet, and in 48 cats fed a corn and poultry meal-based dry diet across four different colonies to ensure that these conditions were not specific to one colony. Digestibility tests in all four colonies used the standard AAFCO digestibility protocol. Diet

and stool analysis were conducted at the same laboratory in order to remove analytical variation. Additionally, 12 cats with age ranging from 1 to 7 years with normal fat digestibility were also fed the same diets in each colony.

Cats across four different colonies showed similar results. The incidence of low fat digestibility increased with advancing age. Approximately 10 to 15% of cats aged 8 to 12 years had low fat digestibility and over 30% cats aged over 12 years had low fat digestibility. Young cats (1 to 7 years) had a very low incidence of reduced fat digestibility.

Similar to fat digestibility, cats across four different colonies showed low protein digestibility. The incidence of reduced protein digestibility is not as dramatic as low fat digestibility, but there is a gradual increased incidence of reduced protein digestibility with advancing age.

Nutrient digestibility declines with age in several mammalian species. Digestibility studies with dogs reported little evidence of an age-related decline in digestive efficiency.^{4,5,6,7}

Figure 3: Percent of cats with low fat digestibility (pooled data from four colonies).

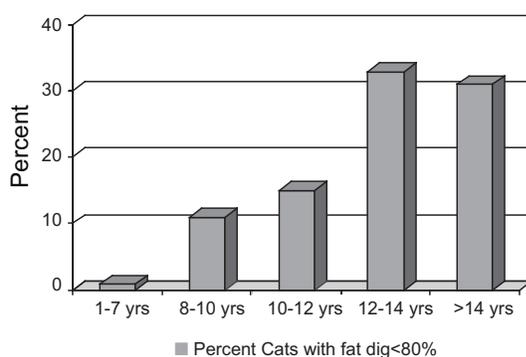
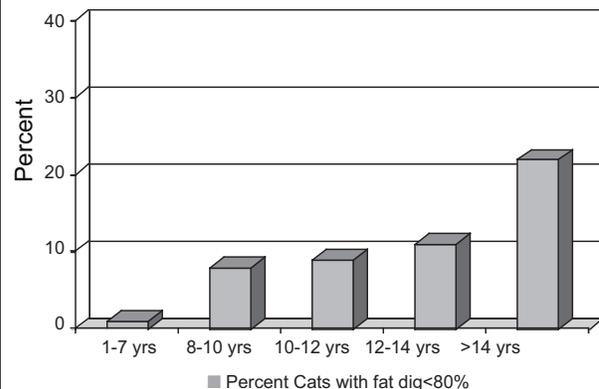


Figure 4: Percent of cats with low protein digestibility (pooled data from four colonies).



Very little information is available in the literature regarding the effect of age on digestive function in cats. Taylor et al.⁸ reported a significant decrease in nutrient digestibility with age in cats.

Senior Cats — Obesity or Underweight

Many studies have been conducted in cats to address the prevention of obesity. However, very little attention has been given to address the opposite problem of the skinny, frail cat with low body weight and poor body condition. A significant number of geriatric cats may suffer from this condition.

Perez-Camargo⁹ reported historical NPPC colony body weight data in 235 cats. Cats were divided into three age groups: adult (1 to 7 years, n=114), mature (7 to 12 years, n=39), and geriatric (>12 years, n=82). The mean body weight of cats was approximately 4 kg. A cat was considered obese if the body weight was 50% greater than the mean body weight, and was considered underweight if the body weight was less than 50% of the mean body weight. The data showed that the incidence of obesity happened mainly during the mature stage, while underweight condition was most prevalent in the geriatric life stage. In the mature life stage, 28% of cats (11/39) were found to be obese and only one cat was underweight. The trend was almost reversed during the geriatric life stage. In geriatric cats, 23% of cats (19/82) were found to be underweight and only one cat was obese.

Table 1. Incidence of obesity and underweight by age.

Age group	BW (kg)	Obesity Incidence	Percent Underweight Incidence
Adult (1-7 years)	3.7 ± 0.8 a	<1%	<1%
Mature (7-12 years)	4.4 ± 1.7 b	28%	<1%
Geriatric (>12 years)	2.9 ± 1.0 c	<1%	23%

Harper¹⁰ reported retrospective body weight data of 53 healthy cats over 11 years of age. Between 5 to 8 years of age, 50% of cats gained body weight, while 35% maintained weight, and 15% lost more than 10% body weight. From 8 to 11 years of age, 20% gained weight, 50% maintained weight, and 30% lost weight. Data from these studies indicate that in senior cats (> 11 years of age), weight maintenance or loss is much more common than weight gain.

In humans and dogs, age-related declines in maintenance energy requirements (MER) are related to decreased physical activity, with a smaller contribution from decreased basal metabolic rate. In contrast to humans or dogs, cats do not appear to exhibit an age-related decline in MER.¹¹

In a long-term feeding study¹² of cats ranging in age from 10 to 15 years, cats were fed fish-based wet foods. Only data from cats that were able to maintain body weight were considered. Total calorie intake/kg BW in cats increased with ad-

vancing age to maintain body weight. It is possible that the increase in total calorie consumption in these cats could be to compensate for some decrease in digestive capacity. Despite this compensation by some cats, there were several cats over the age of 13 that were not able to maintain body weight. No cat over the age of 15 was used in the study as none was able to maintain body weight. When body weight data for all cats was presented in relation to age there was a significant decline in body weight with advancing age (Figure 5).

In some instances, an underweight condition or weight loss is related to specific diseases; however, reduced ability to digest fat and protein may contribute to the development of weight loss and underweight conditions even in otherwise apparently healthy cats. Perez-Camargo⁹ reported average body weight change of 258 cats during the four years prior to their death. Body weight declined gradually during the geriatric life stage, however, there was a dramatic decrease during the last year of a cat's life regardless of the cause of death.

Fat is the most energy-dense macronutrient and an impaired ability to digest fat could contribute, at least in part, to the negative changes in BW and body condition in geriatric cats. It is likely that the onset of reduced fat digestibility is gradual, but over the long term may contribute negatively to energy balance in a large number of geriatric cats.

Nutrient Digestibility Affects Other Health Measures

A study was conducted to evaluate the relationship between fat and protein digestibility with several health measures. Seventy senior cats (7 to 17 years) were fed a standard wet food until their natural death. Digestibility testing was conducted every six months. Blood samples for serum vitamin E, vitamin B12, folate, and pancreatic lipase immunoreactivity (PLI); body condition scores (5-point scale); body composition by dual energy X-ray absorptiometry (DEXA); and skin-fold thickness measurements were taken on the same cats when digestibility was determined.

Correlation analysis was performed on the data between fat and protein digestibility and the other variables. To calculate correlations, analysis of covariance was used wherein fat or protein digestibility was the dependent variable and the independent variables were time, cats and each of the other variables.

Table 2 indicates that several health measures were correlated with fat digestibility. The relationship was significant (P<0.05) in all cases, but the correlation values showed variability among the different parameters. A strong positive relationship existed between fat digestibility and vitamin E. This was not unexpected as vitamin E is fat soluble, and in cats exhibiting low fat digestibility, the serum vitamin E levels were generally lower. In some cats with poor fat digestibility, the serum vitamin E levels were below 5 mg/L. Inadequate vita-

Table 2. Important correlations of fat digestibility and health measures.

Correlated with Fat Digestibility	Correlation	P-Value
Age (years)	-0.76	<0.0001
Vitamin E (mg/L)	0.65	<0.0001
Vitamin B12 (ng/L)	0.60	0.0001
PLI (ug/L)	-0.52	0.0422
Skin Thickness (mm)	0.36	0.0229
Body Condition Score	0.46	0.0001
Tissue Fat by DEXA (%)	0.43	0.0027

min E uptake can result in health problems including steatitis.¹³ Gershoff and Norkin¹⁴ reported serum vitamin E levels of 0.3-5.0 mg/L in cats fed a vitamin E deficient diet. Thus, the low fat digestibility condition observed in some cats may lower serum vitamin E levels similar to those produced in cats given vitamin E deficient diets. Other fat soluble vitamins (A, D, K) were not measured, but it is possible that a similar relationship existed between fat digestibility and other fat soluble vitamins.

Vitamin B12 also showed a strong positive correlation with fat and protein digestibility, with some cats showing levels below 200ng/L. Simpson¹⁵ reported subnormal concentrations of vitamin B12 in plasma of cats exhibiting weight loss due to various reasons such as diarrhea, anorexia, thickened intestines and vomiting.

Body condition score, tissue fat and skin thickness were positively correlated with fat digestibility. Most cats with low fat digestibility showed a body condition score below 2.5 (on a 5-point scale) and a skin thickness below 2 mm.

Table 3 shows correlations of several health measures with protein digestibility. Vitamins E and B12 showed correlations similar to those that were observed with fat digestibility. There was also a positive correlation with lean body mass and body condition score. Perez-Camargo⁹ reported body composition changes with age in 256 cats. During the adult life stage, average body fat was 10%, peaked to 18% during the mature life stage, and then progressively dropped after 12 years of age. Lean body mass (grams) was highest in the adult life stage, declined gradually with age, and at age 15, cats had lean body mass 30% less than the average lean body mass of healthy adult cats. Decreases in both body fat and lean body mass with advancing age may contribute to the frail look of many geriatric cats. Reduced protein digestibility with age may contribute to predisposing cats over age 12 to have a negative nitrogen balance and loss of lean body mass. The correlation data presented above suggests that some of the health changes in geriatric cats may be attributed to reduced digestive capacity that occurs with advancing age.

Table 3. Correlations of protein digestibility and health measures.

Correlated with Protein Digestibility	Correlation	P-Value
Age (years)	-0.66	0.0003
Vitamin E (mg/L)	0.60	<0.0001
Vitamin B12 (ng/L)	0.63	0.0002
Lean Body Mass by DEXA (g)	0.49	0.0069
Body Condition Score	0.47	0.0001
Folate (ug/L)	0.42	0.0767
Tissue Fat by DEXA (%)	0.35	0.0385

Identifying Cats with Reduced Digestive Capacity

Digestibility testing often requires lengthy and complicated procedures that are difficult or inconvenient, particularly in clinical situations. Therefore, the correlation data was further examined to potentially develop a quick screening method for identifying cats with reduced fat and protein digestibility in clinical situations. Serum vitamin E and vitamin B12 were shown to have a strong inverse association with reduced digestive function. Based on the literature and internal colony data, abnormal levels were determined for each measure. Table 4 shows the percent of cats with abnormal levels of these parameters that also had low fat (<80%) and low protein (<77%) digestibility.

These data show how blood measures can be used to identify cats suffering from poor digestive capacity. For example, 100% of cats over 7 years of age that had serum vitamin E level below 5 mg/L also had low fat digestibility, and 80% of cats showed low protein digestibility when their serum vitamin E levels were below 5 mg/L. This data were obtained in a study with senior cats (n=70) age 7 to 17 years fed standard wet cat food. These quick diagnostic methods are important for a veterinary practitioner. If a cat presents

Figure 5: Body weight change with age.

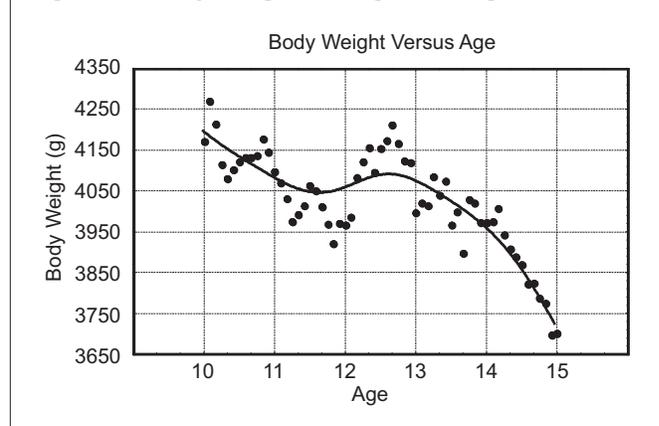


Table 4. Examples of abnormal levels of parameters and percent of cats with low digestibility.

Parameter	Abnormal levels	Percent with low (<80%) fat digestibility	Percent with low protein (<77%) digestibility
Vitamin E	< 5 mg/L	100	80
Vitamin B12	< 100 ng/L	92	67

with low body weight or condition and no specific disease is diagnosed, the practitioner can have a blood sample analyzed for the measures mentioned above to determine if the cat may be suffering from poor fat and/or protein digestion. Furthermore, once the cat is put on a specific dietary regimen or treatment, timely analysis of these measures may show if the cat is improving.

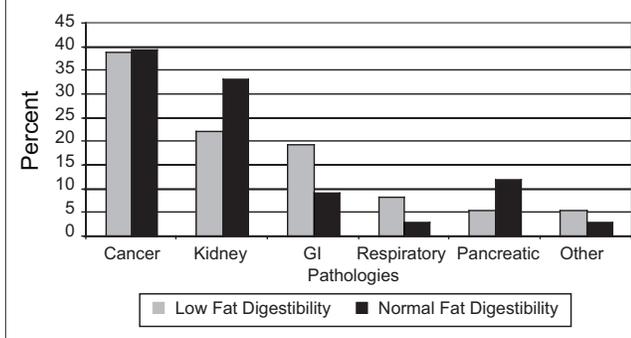
Pathologies in Low Fat Digestibility Cats

Primary cause of death and pathologies at necropsy were examined in senior (7 to 17 years) cats (n=69) fed standard wet cat food. In this study, fat digestibility was determined within six months prior to death. Thirty-six cats showed low fat digestibility and 33 cats showed normal fat digestibility when determined within six months prior to death. High incidence of low fat digestibility in these cats was possibly due to the advanced age when the digestibility was determined.

Figure 5 shows the primary cause of death in these cats, determined by both clinical diagnosis before death and necropsy results. Thirty-nine percent of low and normal fat digestibility cats died of cancer; however, 70% of low fat digestibility cats developed gastrointestinal (GI) related cancer as compared to only 23% of normal fat digestibility cats that had GI-related cancer. Incidence of other GI disease such as enteritis and enterocolitis was also higher in cats with lower than normal fat digestibility.

Although a single primary cause of death was determined for each cat, many cats suffered from multiple pathologies

Figure 6: Primary cause of death in low and normal fat digestibility cats.



observed at necropsy or on histopathology. Figure 7 shows the incidence of pathologies that were reported from the necropsy and histopathology, and is expressed on a percent basis. Data shows that cats suffering from low fat digestibility had a high prevalence of most pathologies compared to cats with normal fat digestibility. It is likely that cats with low fat digestibility may have suffered from multiple pathologies. The prevalence of renal, cancer and GI related pathologies were higher in cats with low fat digestibility than cats with normal fat digestibility.

There are a number of pathologies that could predispose cats to poor digestibility of fats and protein. Malabsorption and maldigestion can occur from almost any diffuse disease of the intestine. Pathologies may originate in the pancreas, liver and/or intestines. Pancreatitis is recognized as the most common disorder of the exocrine pancreas in cats.¹⁶ Despite this, very little is known about its etiology, and its diagnosis remains challenging. Early necropsy studies reported a prevalence of feline pancreatitis from 0.6% to 2.4%^{17,18}; however, in a more recent study,¹⁹ histopathologic examination of pancreatic tissue from 115 healthy and diseased cats showed inflammation of pancreas present in 67% of cats evaluated. Pathologies associated with the pancreas may account for some cases of reduced fat digestibility. Diffuse intestinal diseases, such as intestinal lymphoma, small intestinal bacterial overgrowth, inflammatory bowel disease, and liver disease, may also lead to reduced nutrient absorption in the small intestine. In addition to the disease conditions, age-related changes in digestive physiology, hormones and gut microbiota may directly or indirectly reduce the digestive capacity.²⁰

In the same pool of low and normal fat digestibility cats, we compared mean predicted fat mass (g) and lean body mass (g) for cats prior to death. A longitudinal linear regression model best fit the lean body mass data, and the prediction line showed a general progressive decrease in average lean body mass as the cat neared the end of its life span for both groups of cats.

Figure 7. Percent of pathologies at necropsy — Low and normal fat digestibility cats.

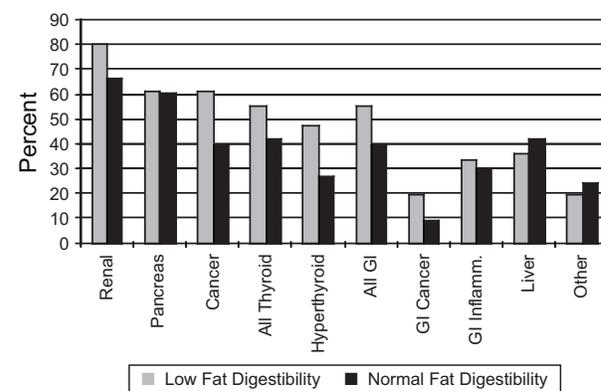
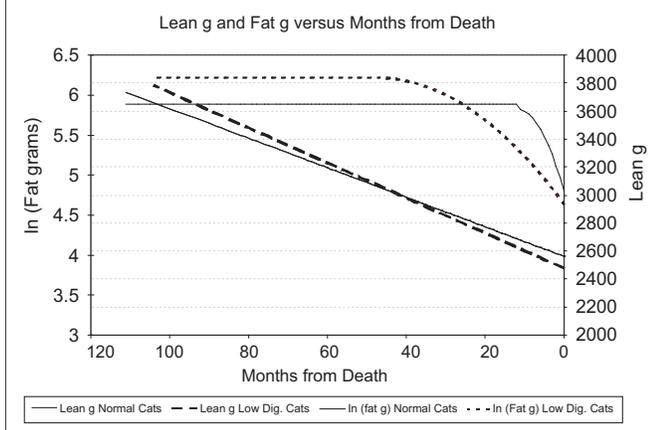


Figure 8. Lean and fat (g) change prior to death.



The fat mass was transformed into natural logarithms to account for extreme observations. A segmented regression model was used, with a quadratic model best fitting the period closest to death. There was a significant difference between the models for low and normal fat digestibility cats. The analysis estimated that cats with low fat digestibility start losing body fat 47 months prior to death much as compared to the cats with normal fat digestibility that start losing body fat 12 months prior to death (Figure 8).

Age-related changes in fecal microflora were studied in 115 cats with ages ranging from 1 to 16 years.²¹ Fecal *bifidobacteria* and *lactobacilli* were lower and fecal *Clostridium* perfringens were higher in mature and geriatric cats than in young and adult cats. The relationship between gut microbiota and nutrient digestion in geriatric cats needs to be studied further. The precise etiology of reduction in nutrient digestibilities in geriatric cats is unknown, and it is likely that there is more than one cause.

Nutritional Recommendations for Cats with Impaired Digestion

Cats that develop age-related weight loss may show decreased muscle mass, increased urine volume, increased stool volume, thin skin, and rough hair coat. It is critical to monitor weight on a regular basis in aging cats. Evaluating percent weight change, rather than just absolute weight, may highlight small but important changes in body weight. Regular physical examination and routine blood work also are important.

Humans and dogs consistently show an age-related decline in MER by approximately 20%, whereas cats reportedly exhibit no such age-related MER decline¹¹; therefore, unless undesirable weight gain is observed, energy provided to geriatric cats should not be reduced. Although some cats can compensate for lower digestive capacity via increasing food intake, many cats cannot and are susceptible to body weight loss.

In geriatric cats, especially with those starting to lose weight,

the major goal is to maintain body weight and body condition by frequent access to highly palatable, highly digestible, nutrient dense foods. In geriatric cats, there is increased risk of losing sense of smell. Therefore, different flavors and textures should be tried to determine which flavors and textures the cat prefers. Dry foods with high energy density, excellent palatability and high digestibility may be used if the cat is able to chew and consume dry food. Canned foods are usually highly palatable and have the advantage of increasing water intake, but are lower in caloric density on a volume basis. Adding warm water to dry food may increase acceptance for some cats and may be easier to chew. Providing food multiple times during the day will help increase food consumption. If the cat continues to lose body weight, and no underlying disease can be identified, then critical care diets with the highest caloric density may be tried.

Further work is needed to identify specific causes of the reduction in digestive capacity that occurs in a large percentage of geriatric cats. It is important to develop a targeted nutritional solution for the skinny condition seen in this population of senior cats.

Acknowledgements

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Q&A Discussion

Q: Dr. Jane Armstrong, University of Minnesota: I wonder if the rather marked incidence of fat digestibility changes are indicative of early pathology that we might consider a specific marker or indication of a variety of disease processes, or how much is reflective of physiologic decline in things that would not cross over into where we could diagnose it as a specific disease process. So, I'm wondering if perhaps some of the cats had very marked declines in PLI (Pancreatic Lipase Immunoreactivity), and if you did any interventions? Did you supplement pancreatic enzymes in any cats that were particularly low or use prebiotics or intervene at all in these cats?

A: Dr. Patil: These cats were on a long-term feeding study so we were not able to do any kind of dietary intervention. They stayed on whatever diet they were getting during that study, but they were treated if they had evidence or clinical signs of disease, such as pancreatic diseases. I might also mention that some of the PLIs didn't always necessarily correlate with pathologies.

Q: Dr. David Williams, University of Illinois: It was very,

very interesting information. Several years ago I presented an abstract at a Nestlé Purina Nutrition Forum showing that among cats with signs of GI disease, 30% that were greater than 10 years of age had low serum cobalamins as opposed to 10% in young cats, which is a remarkable resemblance to some of the data you just presented. My observation is that human beings who present with cobalamin deficiency or pernicious anemia have GI signs that are completely reversed when they are supplemented with cobalamin. So I wonder, but maybe you have answered the question already, did you take any of these cats and replace the cobalamin deficiency? Because it is possible that, as in human beings, a lot of the GI signs you are looking at are secondary to cobalamin deficiency.

A: Dr. Carolyn Cupp, Nestlé Purina Research: Providing supplemental cobalamin would have been considered an interventional therapy in the long-term study and would have invalidated the study, so we couldn't do it on those cats. But in cats that were not on that study, yes, we have tried cobalamin therapy. We were not able to see a normalization of GI function.

Comment: Dr. David Williams, University of Illinois: As a clinical observation, when pet cats are tested for voluminous pale yellow stools, most people think it is pancreatic insufficiency. Maybe 5% of the time it is, but most often it is small intestinal disease associated with severe cobalamin insufficiency. I don't have any figures, but many of those cats respond remarkably well to just cobalamin injections.

Q: Dr. Richard Hill, University of Florida: I wondered whether you had any data on carbohydrate digestibility in these older cats, and whether you could possibly use carbohydrates as a calorie source?

A: Dr. Patil: We did not collect data on carbohydrate digestibility because most of these studies were done using wet cat food. There is very little carbohydrate in wet cat food.

Comment: Dr. Aulus Carciofi, University Sao Paulo: In response to Dr. Hill's question, we have some old cats in which we detected low digestive function, and we tested starch digestibility. It is also reduced in these animals. Also we tried to improve the fat digestibility in these cats adding lecithin to the diet. Maybe if the problem was emulsification we could see some increase in digestibility adding lecithin to the diet. This didn't work. So the problem in fat digestibility is maybe related to enzymes or some other problem.

Q: Dr. Tom Schermerhorn, Kansas State University: I have just a point of clarification and then a question. With regard to the data on body weight changes with age, as I understand

it, it was cross-sectional data of a kennel or cattery, rather than profiles of individual cats' journey through life. So some of the decrease in obesity in old age could simply reflect mortality related with obesity at a certain point. And if that's true, I guess the other question is whether age is a disease or not? I am having a hard time trying to find the line between when these cats are just aging and they become sick. So I think it would be really interesting to see when the veterinarians caring for these cats identified those fading cats as being clinically ill and they had a diagnosis attached to them, rather than just an old cat. I wonder if you have any data on that.

A: Dr. Patil: We do not have that data. However, I showed you one controlled study where we measured digestibility in 140 cats. Each of those cats was screened for any kind of illness prior to the study, so they had at least no diagnosed disease at that point when we did the study. And that population of cats showed a significant decrease in fat digestibility with age.

Comment: Dr. Gerardo Perez-Camargo, Nestlé Purina Research: I would just like to clarify one issue, as we may have confused the audience with multiple data sets from our facility. Earlier, I presented data that was cross-sectional. We looked at body weights across populations of cats, and we identified a decrease in average body weight in cats over 12 years of age. My colleague, Dr. Carolyn Cupp, presented data from a longitudinal study of 90 cats. So her data reflects, as Tom described, profiles of individual cats' journey through life. So we looked both ways with similar results.