

Some nutritional aspects of ageing in dogs and cats

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The specific nutritional requirements of ageing cats and dogs have not been widely studied, and it is only recently that investigations into the processes of ageing in cats and dogs have begun. The increased life expectancy of companion animals, resulting mainly from more sophisticated veterinary care, improved nutrition and heightened owner-awareness, has stimulated interest in the changes associated with ageing and the possible role that nutrition may play in delaying such changes. It has been estimated that approximately 35% of dogs and 30% of cats are aged over 7 years (Venn, 1992). The age at which a cat or dog can be considered old is one of great debate and is particularly complicated in the dog because of the variety of breeds. In general, ageing occurs more rapidly in the larger breeds, with small breeds exhibiting the longest life-span. Thus, giant breeds such as Great Danes are reported to have a life expectancy of about 7–8 years, while toy breeds such as Yorkshire Terriers and Dachshunds have a life expectancy of about 12 years (Legrand-Defretin & Munday, 1993). The maximum life-span achieved by a dog is reportedly 27 years, although it is rare for them to live more than 20 years (Macdougall & Barker, 1984). Cats, on the other hand, do not display a breed-effect with respect to ageing (Griffith, 1968). They have an average life expectancy of 14 years yet the oldest recorded cat is known to have lived for 36 years (Mosier, 1978). The individual variability clearly makes it difficult to have a precise definition of geriatric. It has been suggested that a geriatric cat or dog is one which is in the last third of its anticipated life-span, although perhaps it is more realistic to categorize an animal according to the point at which visible signs of ageing become apparent. The obvious signs of ageing, which are common to both cats and dogs, are whitening of the hair and a general decline in coat condition, failing senses i.e. sight and hearing, and lethargy. In addition, there are often marked behavioural changes including irritability and nervousness (Mosier, 1978).

As well as the more obvious signs of ageing there are a number of metabolic changes associated with ageing cats and dogs which may not be apparent to the owner. For example, there are well-documented changes in body composition, such that in old animals the total cell mass and the amount of intracellular water decrease, total body protein stores decrease and fat stores tend to increase. After middle age, fat stores begin to decrease, although relative to fat-free mass they remain high (Masoro, 1985). Studies with humans have shown a decline in the efficiency of the immune system which results from changes in the differentiation of T lymphocytes. Whether these changes occur in cats and dogs has yet to be demonstrated, but it is generally assumed that this is the case since ageing in all mammals is associated with a decline in immunocompetence (Ross, 1989; Morris, 1994). Other metabolic changes which have been reported to occur in humans, and appear to be characteristic of ageing cats and dogs, include metabolic changes in the functioning of the major organs, i.e. the kidneys, lungs, heart and gastrointestinal tract. Declining kidney function is associated with ageing in all mammals but chronic renal failure is a particular problem of middle-aged and old cats (Rubin,

1989). Dogs, on the other hand, are more susceptible to heart disease and an estimated 30% of aged dogs suffer from endocardiosis. However, epidemiological studies have shown that the most common cause of death by natural causes in old dogs is cancer, followed by kidney failure, pancreatitis and heart failure (Bronson, 1982).

The importance of nutrition in ageing animals lies with the aim of slowing or preventing the progression of such metabolic changes. The capacity to eliminate or at least relieve the clinical signs of ageing and potentially to enhance both life expectancy and quality cannot be underestimated. Consequently, research into the specific nutritional requirements of ageing cats and dogs is progressing, although there are still many areas to be investigated.

CURRENT NUTRITIONAL RECOMMENDATIONS FOR AGEING CATS AND DOGS

It is true to say that there is very little information relating to the nutritional requirements of ageing animals and specifically the requirements of ageing healthy animals. Nutritional therapy for ageing animals with clinical problems is widely practised, particularly for some of the more common disorders. Of these, one of the most prevalent in ageing cats and dogs is obesity and as many as 44% of all dogs are estimated to be overweight (Markham & Hodgkins, 1989). As with humans, severe overweight predisposes cats and dogs to clinical conditions such as diabetes, osteo-arthritis and cardiac problems (Markwell & Butterwick, 1994). Additionally, obesity has been associated also with an increased risk of lower-urinary-tract disease in cats (Willeberg & Priester, 1976). Although factors such as neutering and lack of exercise can exacerbate the tendency towards obesity, a restriction of energy intake is a sensible way to control body weight. It is important to feed diets which are less energy dense without restricting the intake of other essential nutrients. This means that reducing the amount of food offered is not an advisable way to achieve weight loss; reducing total energy intake is the safest practice. The use of fibre in weight-reducing diets is sometimes advocated since, theoretically, this provides low-energy diets which permit substantial food intakes and are thus satiating. However, this rationale is based on human studies which have produced conflicting results, and recent studies with dogs have indicated that the inclusion of dietary fibre in canine diets has no beneficial effect on satiety (Butterwick *et al.* 1994). The dietary management of other clinical problems in ageing animals is well recognized. Renal disease, which is most common in middle-aged and old cats and dogs, can be approached through nutritional therapy (Brown, 1994). The basis for dietary management of renal failure is the restriction of dietary protein (Osborne *et al.* 1982). Additionally, studies with dogs have shown that the restriction of dietary P may help to slow the progression of renal failure (Finco *et al.* 1992). Equally important is the maintenance of an optimum Ca:P value (1.2–1.4:1) to prevent excessive assimilation of phosphates. Likewise, it is usual to restrict dietary Na in cases of renal failure since Na retention contributes to systemic hypertension, a relatively common complicating factor with kidney failure (Moraillon & Wolter, 1994). There are a number of clinical studies which have demonstrated the efficacy of low-protein, low-P and low-Na diets in managing renal disease. However, it should be stressed that in the clinically-normal animal there is no evidence to suggest that restricted dietary protein, P or Na will prevent the onset of renal failure.

There are many more examples of clinical problems of ageing cats and dogs which are

managed by nutritional therapy. What though, of the clinically-healthy old animal? Is there any evidence to indicate that there is an optimum diet for the clinically-normal old cat or dog which is any different from the diet of a young animal? It has been suggested that as part of the normal ageing process there are a number of changes which take place in the gastrointestinal tract, including reduced salivary secretion, reduced gastric acid secretion, decreased villus size and decreased cell turnover (Venn, 1992). One study (Meyer *et al.* 1940) indicated that amylase (EC 3.2.1.1), trypsin (EC 3.4.21.4) and lipase (EC 3.1.1.3) activities in fasting duodenal juice decline with age. However, the mammalian gastrointestinal tract has a large reserve capacity with respect to both digestion and absorption. Consequently there would have to be a considerable decline in function in order to observe a significant decline in digestive efficiency. Pelz *et al.* (1968) reported decreased fat digestibility in elderly men and women, whereas other studies have been unable to demonstrate any effect of age on fat digestibility (Arora *et al.* 1987). Although the studies which have been carried out in humans have produced conflicting results, as yet there is no clear evidence that digestive efficiency declines with age. Nonetheless, there is continued suggestion that healthy older animals may require modified diets to compensate for declining function of the gastrointestinal tract. At the present time there is little evidence to substantiate such claims in old cats and dogs. On the contrary, one study (Sheffy *et al.* 1985) indicated an increased digestive efficiency of elderly beagles (10–12 years) compared with young beagles (1 year). A study by Buffington *et al.* (1989) reported no significant difference in the digestibility coefficients exhibited by 2–3-year-old and 16–17-year-old beagle dogs. There are few equivalent data for cats, although Anantharaman-Barr *et al.* (1991) found no significant differences in digestive efficiency in cats aged 1, 3–5 and >10 years. Nevertheless, in this study the digestibility of fat in the oldest cats was shown to be 0.80 compared with 0.88 in the 3–5 year olds. This is in line with the more recent studies which have indicated a decline in feline digestive function with age (Taylor *et al.* 1995). It is appropriate, therefore, to investigate the effect of ageing on digestibility variables in ageing cats and dogs, since a reduction in digestive efficiency may well indicate the need for modified diets for older animals.

THE EFFECT OF AGEING ON ENERGY INTAKE AND NUTRIENT DIGESTIBILITY IN DOGS

One of the most important aspects of nutrition in the ageing dog is the changing requirement for energy. Human studies indicate a downward trend in energy expenditure associated with age, and a concomitant reduction in energy requirement (Young, 1992). If the same is true for the dog, it needs to be taken into consideration when food is offered otherwise obesity may become a problem. It has been claimed that the energy requirements of old dogs are 20% lower than younger dogs of equal body weight (Barrette, 1990). In order to investigate the maintenance energy requirements of older dogs, and to determine the apparent digestibility of the macronutrients and energy, a study was carried out with twenty-eight adult dogs of different ages.

Study protocol

A group of twenty-eight adult dogs (twelve neutered females and sixteen neutered males) of five different breeds were selected to participate in a 16-week feeding trial. The

Table 1. *Dogs participating in the study*

Breed	Young		Old	
	Male	Female	Male	Female
Cairn terrier	3	2	3	2
Labrador retriever	2	1	1	2
Beagle	2	–	–	2
Smooth-haired dachshund	1	–	1	–
West Highland white terrier	–	1	–	1

dogs were categorized into two age-groups: old (>8 years, n 14) and young (less than 6 years, n 14). Food was offered according to body weight, although rations varied in order to maintain each dog at a stable body weight (within 2% of start weight). Food intakes were recorded daily and body weights measured twice-weekly which allowed meal sizes to be adjusted as needed. Mean metabolizable energy (ME) intake (kJ/d per kg body weight^{0.75}) was calculated from the predicted ME of food using the American Association of Feed Control Officials' values (protein \times 3.5 + fat \times 8.5 + carbohydrate \times 3.5).

In addition to measuring daily ME intake of the dogs which participated in this trial, the apparent digestibility coefficients of protein, fat and energy also were determined. Full faeces collections were carried out for a 4 d period during weeks 2, 8 and 16 of the trial to enable digestibility coefficients to be determined. The mean digestibility coefficient for each animal during the three collection periods was calculated and one-way ANOVA used to determine significant differences between mean values for each breed.

Results and discussion

Of the twenty-eight dogs which started the feeding trial, twenty-four achieved a stable body weight for the duration of the trial. The details of these twenty-four dogs are presented in Table 1. The mean daily ME intake (kJ/kg body weight^{0.75}) for each group of dogs was compared using one-way ANOVA and the results are presented in Table 2. The small numbers of toy dogs made it difficult to determine any real differences between the young and old animals within breeds so the data were grouped together to provide comparisons of the twelve old dogs *v.* the twelve young dogs (Fig. 1). Overall, there was a significant decline in ME intake with the older group of twelve dogs compared with the young group ($P < 0.05$). The change in ME intake represented about 90 kJ/d per kg body weight^{0.75} less for the old dogs than the young, which is equivalent to an 18% reduction in daily energy demand. This is in line with claims that energy requirements decline by about 20% in older dogs, and also supports the findings of previous studies conducted with ageing dogs (Finke, 1991).

There were no significant differences observed between old and young animals with respect to protein, fat or energy digestibility ($P > 0.05$). However, there were tendencies in all cases for the digestibility coefficients to be slightly reduced in the older group of animals (Table 3).

Table 2. *Metabolizable energy (ME) intake of dogs in different age-groups†*

(Mean values and standard deviations)

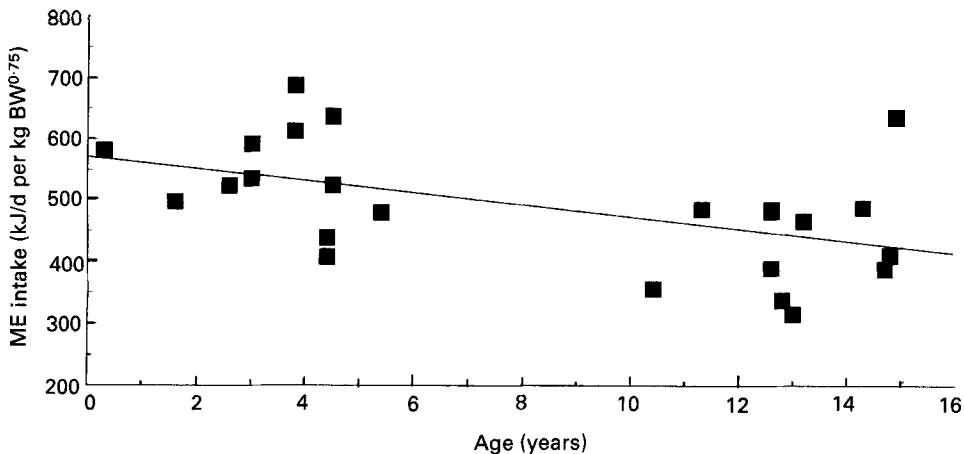
Breed	ME intake (kJ/d per kg BW ^{0.75})			
	Old		Young	
	Mean	SD	Mean	SD
All breeds	448.5*	25.94	538.0	21.75
Cairn terriers	414.6*	30.54	520.4	25.52
Labrador retrievers	393.7*	46.44	608.3	47.27
Beagles‡	610.0	27.61	497.4	17.15
Dachshunds and Westies§	452.7	31.79	523.8	66.10

* Mean values were significantly different from those for young dogs.

† For details of animals and procedures, see Table 1 and pp. 647–648.

‡ Sample size too small to compare statistically.

§ West Highland white terrier.

Fig. 1. Metabolizable energy (ME) intakes of dogs of different ages (kJ/d per kg body weight (BW)^{0.75}). For details of animals and procedures, see Table 1 and pp. 647–648. r^2 22.8; $P < 0.05$.

THE EFFECT OF AGEING ON ENERGY INTAKE AND NUTRIENT DIGESTIBILITY IN CATS

Cats, like dogs, have a tendency towards obesity with advancing age and it may be necessary to restrict energy intake in elderly individuals (Legrand-Defretin & Munday, 1993). However, occasionally inappetence is more of a problem in very old cats and often diets have to be highly palatable to encourage adequate nutrient intake. There is little information on the maintenance energy requirements of ageing cats, which is not surprising since cats are generally allowed unlimited access to food and will regulate energy intake very effectively. Nevertheless, it is interesting to investigate the energy intakes of elderly cats, particularly because of the tendency towards weight gain with

Table 3. *Apparent digestibility coefficient of protein, fat and energy in dogs of different ages**

(Mean values and standard deviations)

	Age (years)		Protein		Fat		Energy	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
All breeds	12.7	1.88	0.840	0.033	0.938	0.017	0.867	0.027
	3.9	1.10	0.857	0.021	0.951	0.018	0.887	0.023
Cairn terriers	13.5	0.92	0.831	0.039	0.935	0.015	0.860	0.022
	3.28	1.17	0.866	0.027	0.955	0.015	0.892	0.024
Labrador retrievers	11.5	1.21	0.847	0.041	0.938	0.019	0.872	0.036
	3.4	0.69	0.851	0.014	0.935	0.016	0.872	0.025
Beagles	11.6	4.66	0.850	0.034	0.945	0.018	0.878	0.030
	5.4	0.00	0.854	0.014	0.942	0.022	0.879	0.027
Dachshunds and Westies†	13.3	1.21	0.834	0.032	0.933	0.017	0.860	0.020
	4.4	0.05	0.860	0.026	0.957	0.013	0.892	0.020

* For details of animals and procedures, see Table 1 and pp. 647–648.

† West Highland white terrier.

increasing age. This may imply that, at some stage, the ability to 'calorie-count' is impaired or alternatively, perhaps weight gain during middle age is simply a normal part of the ageing process. In order to investigate the energy intakes of adult cats of different ages, and to obtain information on the digestive efficiency of older cats the following study was carried out.

Study protocol

The energy intake and apparent digestibility of macronutrients was assessed in a group of cats of various ages. Forty-eight adult cats participated in the study (twenty-nine entire females, nineteen neutered males). The cats were grouped according to age, thus there were six groups each of eight cats, in the age ranges 1–2, 2–4, 4–6, 6–8, 8–10 and 12–14 years. To ensure that all the cats were of equivalent health status, the day before the trial started every cat was given a routine veterinary examination and blood samples were taken for routine biochemistry and haematology, triiodothyronine, thyroxine and free thyroxine, feline immunodeficiency virus (FIV) and feline leukaemia virus (FeLV). Although all the cats at the Waltham Centre for Pet Nutrition are virus-free, it was decided to carry out the tests for the purposes of completeness of the trial. During the course of the trial every cat was weighed weekly. Urine specific gravities were measured daily. The blood measurements were repeated in the middle of the trial (biochemistry and haematology only) and at the end of the trial (biochemistry, haematology and thyroid hormones). At the end of the trial the body composition of every cat was assessed using dual X-ray absorptiometry (DXA). Although this technique is as yet unvalidated, it is very precise and, thus, suitable for comparative studies such as the present study.

Two nutritionally complete diets which had been analysed for proximate nutrients and energy were offered to the cats: a commercial canned diet (WHISKAS®; Pedigree Petfoods, Melton Mowbray, Leics) and the same diet with an increased level of dietary fibre (+ 4 g guar gum/kg). Over two feeding periods of 4 weeks, each diet was fed to four

cats in each group according to a balanced design. Each cat was offered 350 g food/d and water was available *ad lib*. Daily food intakes were recorded. The cats were allowed a 1-week pre-feed of the diet, then the diet was fed for a further 3 weeks during which time all faeces were collected. Following collection, the faeces were homogenized, freeze-dried and analysed for proximate nutrients. Gross energy content was determined by bomb calorimetry. The digestibility coefficients of the macronutrients and energy were calculated and individual results compared using regression analysis. Where there was significant linear regression, individual data were categorized by age-group and the results compared using one-way ANOVA. Although one of the aims of this study was to investigate the response of cats to dietary guar gum, for the purposes of the present paper only the data concerning the standard diet are considered.

Results and discussion

Of the forty-eight cats which started the trial one had to be substituted because of low food intakes. This cat was replaced with a cat of the same age and sex and a similar body weight, following the first 4-week feeding period.

Every cat tested negative for FIV and FeLV. The levels of thyroid hormones were all within the normal ranges expected for adult cats. The values for blood biochemistry and haematology were within the normal ranges for adult cats at all stages of the trial except for one of the oldest cats which was found to have high circulating levels of urea and creatinine, suggestive of compromised renal function. Although this cat completed the trial, the data were excluded from the final analysis. The urine specific gravities were all within the normal ranges for adult cats (1.02–1.04). These results indicate that all the cats which participated in the trial were clinically healthy and, therefore, any differences in the observed results could not be attributed to compromised health status.

The ME intakes were calculated using the National Research Council (1986) recommended equation for predicting the ME content of food. Daily ME intake (kJ) was expressed per kg body weight. The food intake values indicated a slight trend towards a decrease in daily ME intake with the cats aged up to 10 years, although this was not significant (Fig. 2). However, the values for the seven oldest cats did not fit this trend. Multiple-range analysis indicated that, as a group, these cats had significantly higher ME intakes than all of the other groups ($P < 0.001$). The ME intakes were then expressed per kg lean body mass (measured using DXA). Since lean body mass contains cells which are more metabolically active than fat cells it was possible that the high energy intakes were linked to a relatively high energy demand consistent with proportionately more lean tissue. However, this proved not to be the case. The results are presented in Fig. 3. The trend was the same as previously observed, i.e. significantly higher daily ME intakes for the oldest group of cats per kg lean body mass. This clearly indicated that the high ME intakes were not linked to a proportionately higher lean body mass and, thus, some other factor must be involved.

With respect to the apparent digestibility coefficients, the digestibility value for energy was determined for cats of all ages. However, this is an ongoing study and at this stage the protein and fat digestibility data have only been obtained for the cats aged up to 10 years. The carbohydrate content of canned cat food is very low (usually about 10 g/kg) and, therefore, in this case the determination of carbohydrate digestibility was considered inappropriate.

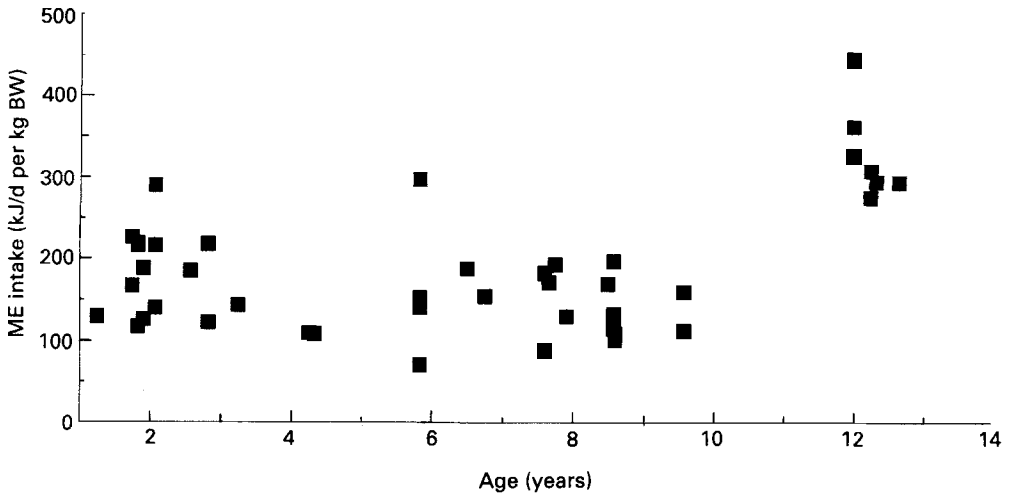


Fig. 2. Predicted metabolizable energy (ME) intake (kJ/d per kg body weight (BW)) of cats of different ages. For details of animals and procedures, see pp. 650–651.

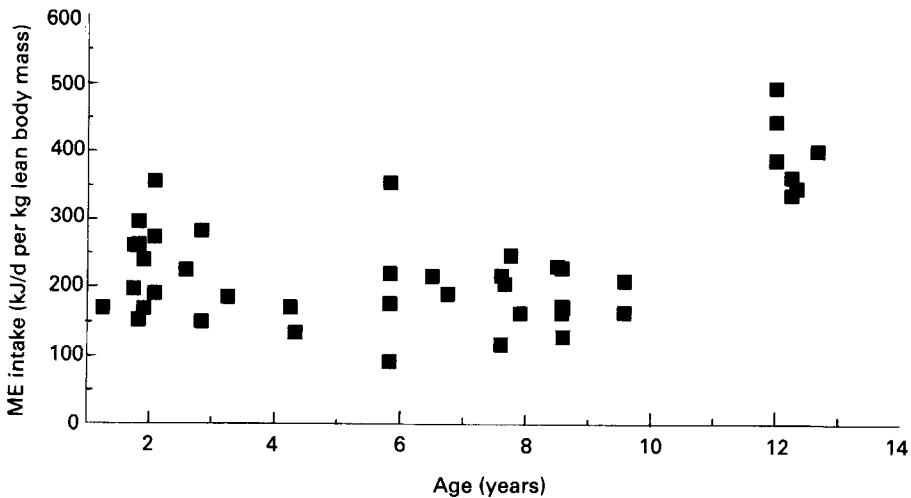


Fig. 3. Predicted metabolizable energy (ME) intakes (kJ/d per kg lean body mass) in cats of different ages. For details of animals and procedures, see pp. 650–651.

The digestibility coefficients for protein and fat were all within the normal ranges exhibited by cats fed on canned cat food (Figs. 4 and 5). There was a slight trend towards a decrease in the apparent digestibility of protein with age, although this was not significant ($P=0.08$). The digestibility coefficient for fat, however, showed a negative linear relationship with age which was significant ($P<0.05$). There was no significant difference between male and female cats with respect to the apparent digestibility of fat ($P>0.05$). The combined effect of a trend towards reduced protein digestibility and a

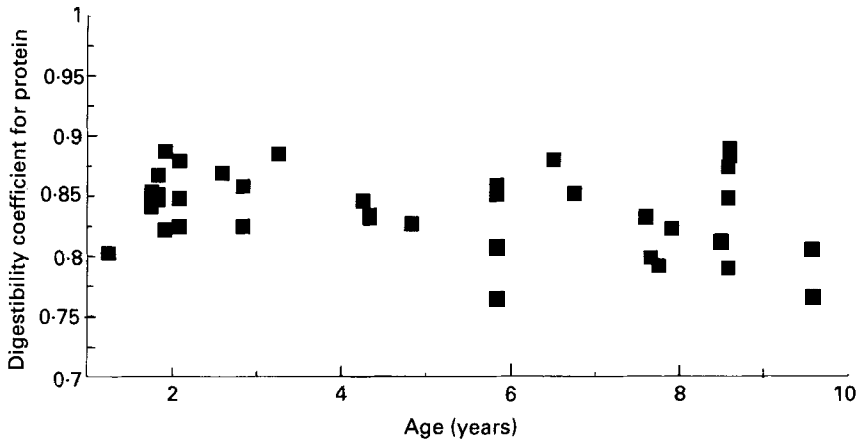


Fig. 4. Relationship between age and protein digestibility in cats. For details of animals and procedures, see pp. 650–651. $P=0.08$.

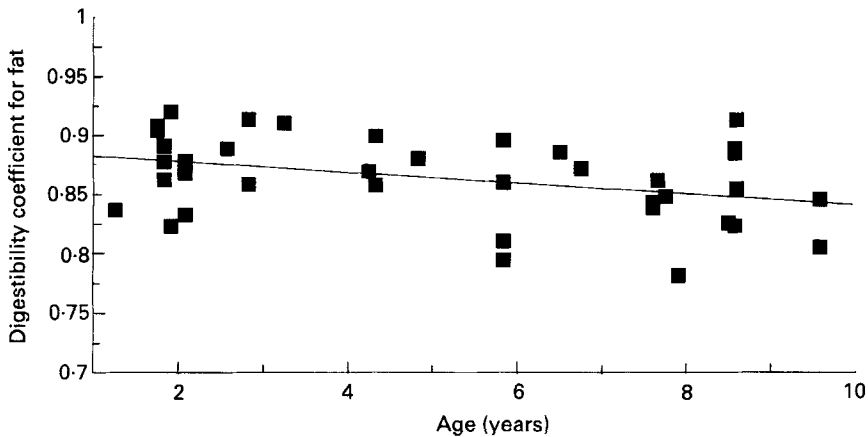


Fig. 5. Relationship between age and fat digestibility in cats. For details of animals and procedures, see pp. 650–651. r^2 13.13; $P=0.025$.

significant increase in fat digestibility with age led to a highly significant negative relationship between the apparent digestibility of energy and age ($P<0.001$). The results are presented in Fig. 6. Multiple-range testing (Duncan's) indicated that the oldest group (12–14 years) exhibited a significantly lower digestibility coefficient for energy than the other five groups ($P<0.01$). This evident decrease in energy digestibility, therefore, would seem to be linked to the unusually high ME intakes demonstrated by the same group of cats. When the digestible energy (DE) values are expressed per kg body weight (Fig. 7) it can be seen that there is no significant difference between the DE intakes of the oldest group of cats and the other groups. Thus, it is apparent that digestive function in the oldest group of cats was compromised to the extent that very high food intakes were required in order for the cats to achieve their energy requirement. These results are

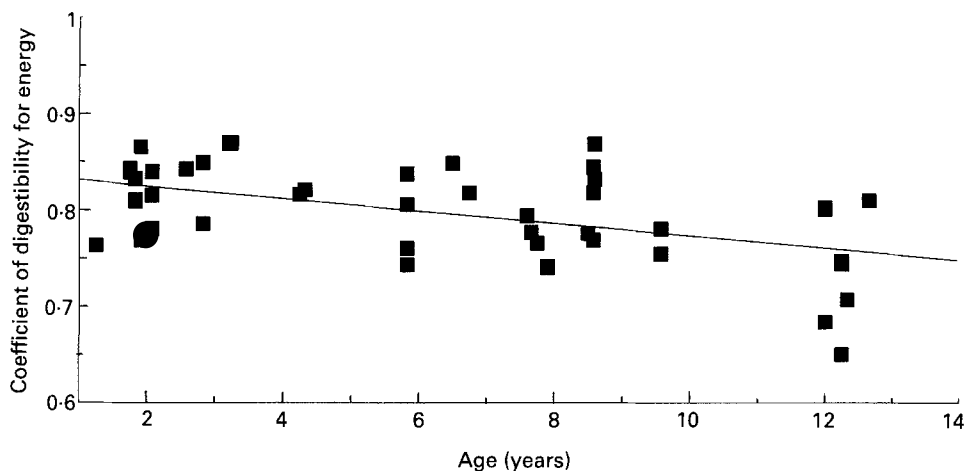


Fig. 6. Relationship between age and energy digestibility in cats. For details of animals and procedures, see pp. 650–651. r^2 25.1; $P=0.0006$.

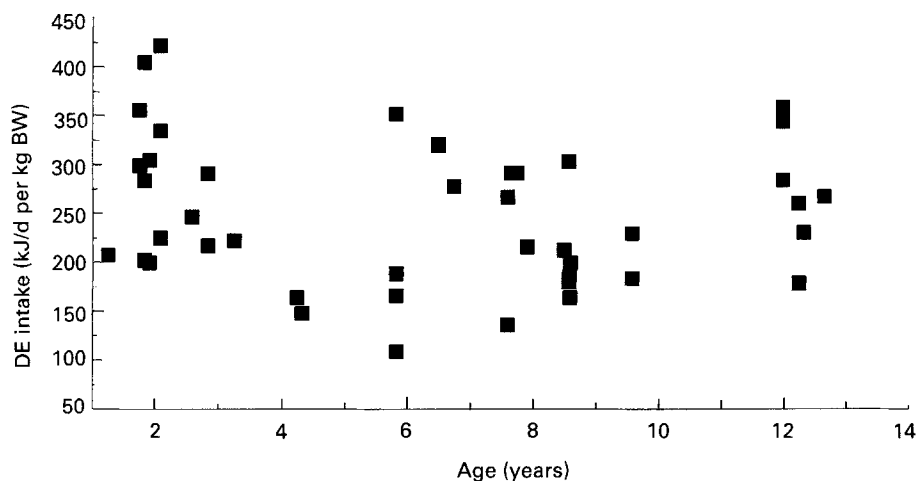


Fig. 7. Digestible energy (DE) intake (kJ/d per kg body weight (BW)) of cats of different ages. For details of animals and procedures, see pp. 650–651.

interesting, particularly since they contradict, to some extent, suggestions that energy intake declines with age (Barrette, 1990). However, when the measured ME intakes are calculated using energy digestibility corrected for protein losses via the urine (National Research Council, 1986), a different picture emerges. There was a significant negative relationship between measured ME intake (per kg body weight) and age in cats up to the age of 10 years ($P<0.05$). This suggests a decline in ME requirements with age which may be linked to a decreased BMR. It has previously been shown that the changes in body composition associated with ageing, i.e. reduced lean body mass and increased fat mass, are consistent with a decline in energy requirements (Cohn *et al.* 1980).

One of the most interesting aspects of the findings of the present study was the evident

ability of the cats to control their energy intake effectively and, thus, maintain body weight. A further point is that since the predictive equation overestimated the ME available to the older cats it may be the case that a modified equation, appropriate to the digestive capacity of old cats, is determined.

CONCLUSIONS

There is clear evidence that as cats and dogs age the requirement for energy declines. This is probably linked to changes in body composition which in turn affect the BMR. Additionally, a decline in physical activity which is normally observed in older animals results in reduced energy requirement. It appears that cats continue to regulate their energy intake, well into advanced age, such that maintenance of a desirable body weight is less of a problem than with dogs.

Studies have indicated little effect of age on the apparent digestibility of protein. However, cats exhibited a significant decline in the capacity to digest fat, which resulted in an overall reduction in energy digestibility. At the present time there is no explanation as to why this should be so. There have been studies with rats which have indicated that pancreatic secretions are reduced by up to 20% of maximal values in old animals. Clearly, decreased pancreatic secretion of lipase limits lipid hydrolysis which in turn could diminish the overall digestion of dietary lipids (Hollander, 1988). However, no such observations have been reported in cats and dogs. Alternatively, it is possible that a decrease in bile acid secretions may be characteristic of old age, thus limiting breakdown of dietary lipids (Mosier, 1978). Again, this has not been demonstrated in cats and dogs but is a potential area for investigation given that protein digestibility appears to remain relatively consistent throughout life.

It is interesting to speculate that perhaps the decline in energy digestibility goes hand in hand with a decreased maintenance energy requirement. It is possible that declining gastrointestinal function is a normal characteristic of ageing, helping the body to maintain correct body weight.

Studies to date have begun the process of defining the nutritional changes associated with ageing in cats and dogs. However, there are many questions which remain unanswered, with respect to both macronutrients and micronutrients and their roles in feline and canine nutrition. The greater the understanding of the role which nutrition can play in delaying the ageing process, the greater the chance we have of offering optimum quality of life to our companion animals.

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