Nutrition for Health

Changing Perspectives on Aging and Energy Requirements: Aging and Digestive Function in Humans, Dogs and Cats

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ABSTRACT

When considering the question of energy balance, it is important to take into account energy provision and the ability of aging animals to digest macronutrients and thus obtain their maintenance energy requirement. A large number of studies have been conducted in humans in an effort to establish whether aging of the gastrointestinal tract has a significant effect on availability of dietary energy. The results of these studies have been conflicting, with indications that some aspects of gut functionality do decline with age, but little evidence overall to suggest that aging humans are at risk of energy deficit due to compromised digestive efficiency. A number of digestibility studies carried out with dogs confirm that there is no evidence of an age-related decline in digestive efficiency. This knowledge makes the determination of energy provision to senior dogs relatively straightforward to calculate. Many senior cats appear to exhibit a marked reduction in their ability to digest macronutrients, particularly fat, efficiently. Because this reduces the overall capacity to obtain energy from the diet, it is recommended that old cats should not routinely be offered reduced energy diets. For senior cats, the feeding regimen in later life should be to offer highly digestible diets that provide as much energy as adult maintenance rations. J. Nutr. 128: 2632S–2635S, 1998.

KEY WORDS: • cats • dogs • aging • digestibility • energy

There is a considerable body of evidence to support the fact that maintenance energy requirement (MER) declines by ~20% in elderly humans and in dogs, although there is no equivalent decrement in cats. One important aspect of the whole energy balance equation is energy provision and the ability of aging animals to digest macronutrients and thus obtain their MER. Clearly, if digestive capability declines with age, it may be inappropriate to reduce dietary energy provision because this may precipitate negative energy balance. It is therefore important to understand the effect of aging on energy digestibility in dogs and cats to determine the correct dietary energy density for body weight maintenance in old age. This paper reviews the information relating to aging and digestive function in humans, dogs and cats and, in the context of our knowledge of age-related changes in energy requirements, how this information can be used to implement appropriate feeding regimens for healthy old cats and dogs.

HUMANS

There have been literally hundreds of studies reported on functionality of the gastrointestinal tract (GIT) and age in humans. For every study that indicates declining GIT efficiency with advancing age, there is another that indicates no age-related effect. Consequently, despite the vast number of studies conducted on this subject, there is no consensus concerning whether healthy old individuals have a reduced capacity for macronutrient digestion. Studies with humans have indicated that, of all the macronutrients, an age-related decline in the capacity to digest fat is the most commonly observed (Pelz et al. 1968). This may be related to diminished pancreatic function because there is some indication that the aging pancreas is relatively insensitive to hormonal stimuli (Khalil et al. 1985). Other studies have indicated that there is a decreased pancreatic lipase secretion in older humans, which has been reported to be ~21%; however, given that lipase is secreted far in excess of requirement, even a reduction in output of 21% is unlikely to have a major effect on fat digestion (Meyer and Necheles 1940). Alternatively, or additionally, the observed reduction in the capacity to digest fat with increasing age may be related to diminished capacity for production, transport and secretion of bile acids. Excretion of chenodeoxycholic acid in the bile decreases with age, probably as a result of an age-dependent decline in hepatic receptor function for exogenous cholesterol. Studies conducted in rats have shown an age-related decline in hepatobiliary transport, and there are also indications that bile acid reabsorption in the terminal ileum is decreased in elderly humans (Hellemans et al. 1984, Kitani 1987). In terms of GIT motility, there does not seem to be any effect of age on orocecal transit time (Husebye and Engedal 1992). There are some indications that colonic transit may slow with age, but results are highly variable and there is little evidence overall to suggest that total transit time changes significantly with increasing age (Madsen 1992). Despite these reported changes in various functional aspects of the human GIT, there is still no unequivocal evi-
dence that aging is accompanied by an inevitable decline in the capacity for fat digestion. Indeed there are studies that have indicated that there is no significant reduction in fat digestibility in aged humans compared with young adults (Arora et al. 1987).

In terms of the other macronutrients, again, there is no conclusive proof that the ability to digest either carbohydrate or protein diminishes with age. There are a number of studies that have noted a decline in both the concentration and the specific activity of various secretions produced in the GIT. There is considerable evidence that both basal and peak gastric acid output decline with age, although there is little apparent age-related change in pepsin secretion (Baron 1963, Goldschmidt et al. 1991). As mentioned previously, there is a general belief that pancreatic function does gradually diminish, although there are conflicting reports on the efficiency with which pancreatic enzymes and bicarbonate are secreted in older subjects. A number of studies have observed no difference in peak volume and bicarbonate secretion after intravenous administration of secretin (Gullo et al. 1983, Rosenberg et al. 1966). Conversely, there have been reports of reduced bicarbonate secretion and up to a 33% reduction in pancreatic amylase and trypsin secretion in aged humans and rats (Fikry 1968, Khalil et al. 1985). There is some evidence that there is a reduction in the concentration of brush border enzymes in aging rats, but at levels that are probably not physiologically important (Greenberg and Holt 1986).

In conclusion, it appears that there are age-related changes in a number of aspects of GIT function; in the majority of healthy individuals, however, these are of little significance. There are probably older individuals whose decreased GIT reserve makes them sensitive to minor insults, but it is unlikely that significant energy deficit is a result of aging itself. In elderly humans whose MER has declined, it is appropriate to reduce energy provision, in the knowledge that the amount of energy derived from macronutrients is likely to remain constant.

### DOGS

There are a number of reports detailing typical apparent digestibility values for healthy adult dogs; these values usually lie between 0.8 and 0.9 (Kendall et al. 1982, Neirinck et al. 1991, Nott et al. 1994). However, relatively few studies have been conducted on the effect of aging on the capacity of the canine gastrointestinal tract to digest and absorb nutrients. One of the earliest reported studies on the effect of age on digestive efficiency was by Lloyd and McCay (1954). In that study, three groups of Beagles representing old dogs (n = 4; mean age, 10.5 y), young adult dogs (n = 4; mean age, 2 y) and puppies (n = 4; mean age, 3 mo) participated in a series of digestibility studies. The apparent digestibility coefficients for protein, fat and carbohydrate were obtained for six different diets, each measured in a 14-d balance study. The results showed no significant effect of age on the apparent digestibility of any of the nutrients measured. Mean protein digestibility was 0.74 for both young and senior dogs, mean fat digestibility was 0.92 and 0.93 for young and old dogs, respectively, and mean carbohydrate digestibility was 0.77 and 0.78 for young and old, respectively. These findings confirmed earlier results reported by Lloyd and McCay (1954) that indicated that increasing age in Beagles was not accompanied by a decline in digestive efficiency. Conversely, the older dogs demonstrated higher apparent digestibility coefficients for fat and protein.

A similar observation was subsequently reported by Sheffy et al. (1985). In that study, apparent digestibility of four commercial diets was measured in a group of young Beagles (n = 8; mean age, 1 y) and a group of old Beagles (n = 8; mean age, 10 y). Nutrient balance for protein, fat and energy was obtained by 5-d total collections, every 4 mo over a 2-y period. The combined values for apparent digestibility coefficients of protein, fat and energy were consistently higher in the older group of dogs than in the younger group. No explanation as to why the older dogs exhibited higher apparent digestibility coefficients was given in the paper.

Additional work with Beagles was reported by Buffington et al. (1989), in which three groups of dogs aged 2–3 (n = 4), 8–10 (n = 5) and 16–17 y (n = 6) participated in a study to measure the apparent digestibility of dietary protein and fat. The mean (± SEM) respective apparent digestibility coefficients for the three groups were 0.77 ± 0.014, 0.78 ± 0.012 and 0.73 ± 0.018 for protein and 0.91 ± 0.01, 0.91 ± 0.004 and 0.86 ± 0.022 for fat. There were no significant differences, and it was therefore concluded that age-related changes in nutrient digestibility are modest in healthy dogs with few differences observable between animals of greatly different ages.

Taylor et al. (1995) measured apparent digestibility of a commercial canned diet in young (n = 12; mean age, 3.9 ± 1.10 y) and old (n = 12; mean age, 12.7 ± 1.88 y) dogs representing five different breeds. A maintenance ration was offered for a 16-wk period during which the apparent digestibility coefficients of protein, fat and energy were determined at wk 2, 8 and 16 using 4-d collections at each time point. The results are presented in Table 1 and indicate no significant age-related change in the apparent digestibility of any of the parameters measured. Both age groups exhibited very similar values and, unlike other reported studies, there was no evidence that the older dogs were able to digest nutrients more efficiently than the young dogs.

From the studies reported, it seems reasonable to conclude that the majority of dogs maintain digestive efficiency as they age. There is some evidence that specific aspects of GIT function may change with age, but the overall efficiency of digestion appears to be maintained.

### TABLE 1

<table>
<thead>
<tr>
<th>Age (y)</th>
<th>Protein</th>
<th>Fat</th>
<th>Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young</td>
<td>12</td>
<td>3.9 ± 1.10</td>
<td>0.857 ± 0.021</td>
</tr>
<tr>
<td>Old</td>
<td>12</td>
<td>12.7 ± 1.88</td>
<td>0.840 ± 0.033</td>
</tr>
</tbody>
</table>

1 Adapted from Taylor et al. (1995).
2 Dog breeds represented by Cairn Terriers (n = 10), Labrador Retrievers (n = 6), Beagles (n = 4), Smooth-haired Dachshunds (n = 2), West Highland White Terriers (n = 2).
3 Values are means ± sd. There were no significant differences between age groups.
function such as hydrochloric acid production and bile acid secretion are diminished in aging dogs but, as with humans, these have little overall significance (Mosier 1987). It is probable that some individuals might exhibit a reduction in apparent digestibility of nutrients; this is borne out by Buffington et al. (1989), who observed a higher variability in the old Beagles in terms of macronutrient digestibility. However, on the basis of current data, it is safe to assume that the majority of senior dogs are able to derive energy from their diets as efficiently as young adult dogs. This knowledge makes the determination of energy provision to senior dogs relatively straightforward to calculate. Because MER declines by ~20% and energy digestibility remains constant, senior dogs should be offered a reduction in energy equivalent to a 20% decrement.

CATS

There is remarkably little information available on the effect of age on digestive function in cats. Anantharaman-Barr et al. (1991) presented the results of a digestibility study with young (n = 7; age, 1 y), middle-aged (n = 8; age, 3–5 y) and old (n = 7, age, >10 y) cats. The results were somewhat inconclusive, indicating an increase in apparent protein digestibility in the oldest group (0.88 compared with 0.83 for the youngest group), whereas the converse was reported for fat, with the oldest group exhibiting an apparent fat digestibility value of 0.80 compared with 0.89 for the 3- to 5-y olds. Overall apparent energy digestibility was not different among the three groups.

In a study from which preliminary results were reported by Taylor et al. (1995), 56 healthy adult British domestic short-haired cats (20 neutered males and 36 entire females; age range, 18 mo–13 y) from the catteries at the Waltham Centre participated in a series of digestibility trials. After a 1-wk dietary adaptation period, the cats were housed individually for 3 wk with continued free access to a canned diet and fresh water. Individual daily food intakes were recorded and full feces collections were carried out with apparent digestibility determined after every 7-d collection. The three digestibility values for each cat were averaged, and the mean value used for statistical comparisons between animals. There was a highly significant relationship between age and daily food intake. The food, and therefore energy intakes for the 16 cats aged between 10 and 14 y were significantly higher than those for the other cats (P < 0.05). When expressed as energy intake relative to body weight, the same profile was evident. However, there was a significant age-related decline in the apparent digestibility of fat, protein and energy. Typically, apparent energy digestibility coefficients were between 0.8 and 0.9 for the younger adults (<7 y), whereas the values for the older cats were clustered between 0.7 and 0.8 (Fig. 1). When digestible energy intake was measured, there was no significant age-related effect (P > 0.05), which indicates that the older cats with compromised digestive function simply increased their daily food intake to compensate for reduced ability to digest the macronutrients. Thus the evidence suggests strongly that cats continue to control energy intake as they age, despite the fact that many cats may exhibit compromised digestive efficiency.

The reasons why clinically healthy cats should display such a marked reduction in their ability to digest dietary macronutrients is unclear. There is virtually no information on the effect of age on feline GIT morphology, transit times or secretory capacities. One study has been reported on aging and orocecal transit time in cats (Papasouliotis et al. 1996). In that study, a comparison of orocecal transit time, as measured by breath hydrogen output, was made in young adult cats (n = 9; age range, 3–5 y) and old adult cats (n = 9; age range, 12–15 y). The values for orocecal transit time in the young group ranged from 180 to 345 min compared with 225–375 min in the older cats. This study demonstrated no significant difference in the median transit times between the two groups.

Both of the reported studies on feline aging and digestive function (Anantharaman-Barr et al. 1991, Taylor et al. 1995) identify fat digestibility as the most problematic in old age. This is interesting because human studies also indicate that, of all the macronutrients, fat digestibility is the only one that
seems to be compromised with advancing age. The plethora of studies on human aging and the GIT indicate some of the factors that may be causal in reduced capacity to digest fat, including reduced secretion and specific activity of pancreatic lipase and reduced capacity for production, transport and secretion of bile acids. Given the cat’s unusual bile acid metabolism, in that taurine is used preferentially for bile acid conjugation, it would be fascinating to investigate the effect of aging on taurine transport and bile acid conjugation in this species (Rabin et al. 1976). In the meantime, we can only speculate as to the causes of the observations. In light of the knowledge on energy requirements of aging cats, however, this information serves only to reinforce the view that old cats should not routinely be offered reduced energy, and hence reduced fat diets. For senior cats, which maintain energy requirement because of their unique behavior, but often exhibit a diminished capacity to derive energy from their diet, the feeding regimen in later life should be to offer highly digestible diets that provide as much energy as adult maintenance rations.

LITERATURE CITED


