INFLUENCE OF SIZE ON THE DOG’S DIGESTIVE FUNCTION

INFLUENCE DE LA TAILLE SUR LA FONCTION DIGESTIVE CHEZ LE CHIEN

By Mickaël WEBER

Les chiens de grande taille -Schnauzers géants et Dogues allemands- sont predisposés à une moins bonne tolérance digestive (selles humides et peu consistantes) que les chiens de petit format -Schnauzers moyens et Caniches nains-, nourris avec le même aliment.

- Cette faible tolérance digestive des grands chiens ne semble pas s’expliquer par une moindre efficacité digestive ni par des temps de vidange gastrique et de transit dans l’intestin grêle plus courts.
- En revanche, une moindre absorption des électrolytes ainsi qu’une plus forte activité fermentaire pourraient être deux causes expliquant la faible qualité de leurs selles.
- Ce travail contribue à une meilleure connaissance de nombreux paramètres de la fonction digestive chez des chiens de différentes tailles. Il apporte également des éléments de réponses nutritionnelles quant à la faible tolérance digestive des grands chiens.

Mots-clés : chiens, races, tolérance digestive, fonction digestive.

SUMMARY

Large-breed dogs – Giant Schnauzers and Great Danes – are predisposed to a greater frequency of soft stools compared with Standard Schnauzers and Miniature Poodles fed the same diet.

- Neither lower digestive efficiency nor upper gastrointestinal transit time appears to explain the poor fecal quality of these large-breed dogs.
- Nevertheless, a low electrolyte absorption and an increased fermentative activity could be two possible causes of their poor digestive tolerance.
- They could be explained, at least in part, by an increased intestinal permeability and a prolonged colonic transit time respectively.
- This work contributes to a better knowledge of a substantial number of parameters measuring gastrointestinal function based on size. It also supplies some nutritional answers to the problem of soft stools in large-breed dogs.

Key words: dogs, breeds, digestive tolerance, digestive function.

RéSUMÉ

Les chiens de grande taille -Schnauzers géants et Dogues allemands- sont predisposés à une moins bonne tolérance digestive (selles humides et peu consistantes) que les chiens de petit format -Schnauzers moyens et Caniches nains-, nourris avec le même aliment.

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- En revanche, une moindre absorption des électrolytes ainsi qu’une plus forte activité fermentaire pourraient être deux causes expliquant la faible qualité de leurs selles.
- Celles-ci pourraient être expliquées respectivement par une perméabilité intestinale plus élevée et par un temps de transit colique très long.
- Ce travail contribue à une meilleure connaissance de nombreux paramètres de la fonction digestive chez des chiens de différentes tailles. Il apporte également des éléments de réponses nutritionnelles quant à la faible tolérance digestive des grands chiens.

Mots-dés : chiens, races, tolérance digestive, fonction digestive.

(1) PhD., Scientific Communication, Royal Canin Research Centre, Aimargues, France.
INTRODUCTION

The canine species, which includes about 400 breeds, is characterized by extreme variability in weight and size, with weight ranging from 1 kg for a Chihuahua to 100 kg for a St Bernard. Empirical observations seem to indicate that certain foods may not be tolerated in the same way, depending on whether a dog is large or small. There is actually a high positive correlation between stool moisture or consistency and dog size, independent of the diet (Meyer et al. 1999). Although unproven at this time, such poor digestive tolerance in large dogs compared to that of small dogs could be the result of anatomic differences. The gastrointestinal tract of a 5-kg dog represents approximately 7% of its body mass, whereas the gastrointestinal tract represents only 2.8% of the body mass in a 60-kg dog (Meyer et al. 1993). The differences in stool quality could also be explained by physiological differences attributable to size.

The goals of this study were to compare different parameters of the digestive function in dogs varying in body size in order to identify the reasons for poor digestive tolerance in large-breed dogs.

Materials and methods

• Animals

Four dog breeds were included in the study, representative of the great diversity in weight and size in the canine species. The sample was made up of 6 Miniature Poodles (MP) (3.5±0.7kg), 6 Standard Schnauzers (SS) (12.6±0.9kg), 6 Giant Schnauzers (GS) (23.3±1.3kg) and 6 Great Danes (GD) (46.3±1.0kg). All the animals were 60-week-old females. They were housed at the National Veterinary School of Nantes in closed stalls for the entire duration of the study. Clinical and biological examinations were performed before the onset of the study to ensure that the animals were in good health. The conditions were in compliance with the French Agriculture and Fishing Ministry requirements with respect to the protection of laboratory animals. The experimental protocol was approved by the A nimal Use and Care Advisory Committee of Nantes Veterinary School beforehand.

• Diet

All the dogs were given the same experimental dry food (Royal Canin, A imarques, France) containing 39.2% protein, 16.3% fat, 9.8% total dietary fiber, 0.38% sodium and 0.70% potassium measured on a dry matter basis. Each dog received the amount of food necessary to cover its daily caloric needs. Fresh water was available ad libitum throughout the study.

Results

• Effect of size on fecal quality

Consistency of stools for each dog was recorded daily for one month from grades ranging from 1 to 5, with 1 representing hard and dry feces and 5 indicating liquid diarrhea. A 2.5 score was considered as optimum, representing a well-formed stool. Figure 1: Effect of size on fecal moisture content (%) and fecal scoring (mean ± standard deviation) in Miniature Poodles (MP), Standard Schnauzers (SS), Giant Schnauzers (GS) and Great Danes (GD). Fecal scoring ranged from grade 1 (hard and dry feces) to grade 5 (liquid diarrhea). A well-formed feces was represented by the 2.5 grade. The values with different letters for the same parameter are significantly different (p<0.05).

Fecal moisture content was measured from laboratory dry matter analyses. Our results confirmed the predisposition of larger dogs (GS and GD) to poorer fecal consistency (i.e., higher fecal score) and higher fecal water content than smaller dogs (SS and MP) (Figure 1). A strong positive correlation was observed between moisture content and the dogs’ weight (r=0.89; p<0.0001). Several hypotheses could explain this difference, as outlined above.

Considering the lower relative mass of the gastrointestinal tract of large dogs compared with that of small dogs (Meyer et al. 1993), the initial hypothesis was that large-breed dogs have poor digestive efficiency.

• Effect of size on digestive efficiency

Poor digestion of food leads to an accumulation of osmotically active undigested particles in the intestinal tract. This could potentially increase the flux of fluids and undigested nutrients entering the colon, exceed the colonic absorptive capacity, stimulate the microflora, and affect fecal moisture and appearance (Guilford & Strombeck, 1996).
The global digestive capacity of our four breeds was evaluated by measuring the total apparent digestibility of our dry diet (Weber et al. 2003a). Their intestinal absorption capacity was assessed by measuring the urinary excretion of two sugars (D-xylose and 3-O-methyl-D-glucose) actively absorbed by the small intestine (Weber et al. 2002a).

Our results showed that digestibility of dry matter, organic matter, crude protein and gross energy was higher for GS and GD than for small breeds (figure 2). Furthermore, the ratio of urinary xylose to 3-O-methyl-D-glucose was similar in all four breeds, suggesting that transport of these sugars is comparable in small and large dogs. These results suggest that poor fecal quality in large dogs does not appear to be related to lower digestive efficiency.

Many studies have reported a strong relationship between gastrointestinal transit time and poor fecal consistency in humans and animals (Guilford & Strombeck, 1996; Jian et al. 1984; Rolfe et al. 2002). It could also be hypothesized that differences in gastrointestinal transit time exist between small and large dogs.

Table 1: Effect of size on gastrointestinal transit time (in hours) (Weber et al. 2002b, 2003b, Hernot et al. 2003). Values (mean±standard deviation) of gastric emptying half-time (T50), predictive total emptying time (pTGET), small intestinal transit time as well as oro-cecal transit time and total gastrointestinal transit time in MP, SS, GS and GD. The values with different letters on the same line are significantly different.

<table>
<thead>
<tr>
<th></th>
<th>MP</th>
<th>SS</th>
<th>GS</th>
<th>GD</th>
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<tr>
<td><strong>Gastric emptying time</strong></td>
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<tr>
<td>Radiopaque markers</td>
<td>6.4 ± 0.5a</td>
<td>6.5 ± 1.2a</td>
<td>7.8 ± 0.7a</td>
<td>6.4 ± 1.1a</td>
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<tr>
<td>pTGET</td>
<td>18.4 ± 1.5a</td>
<td>16.6 ± 2.0a</td>
<td>19.8 ± 1.7a</td>
<td>16.8 ± 1.5a</td>
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<td><strong>Small intestinal transit time</strong></td>
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<tr>
<td>Radiopaque markers</td>
<td>2.0 ± 0.3a</td>
<td>1.8 ± 0.2a</td>
<td>1.8 ± 0.3a</td>
<td>2.3 ± 0.1a</td>
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<tr>
<td><strong>Orocecal transit time</strong></td>
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<tr>
<td>Radiopaque markers</td>
<td>2.5 ± 0.4a</td>
<td>3.0 ± 0.4a</td>
<td>2.9 ± 0.6a</td>
<td>3.0 ± 0.2a</td>
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<td>Sulfasalazine method</td>
<td>2.2 ± 0.5a</td>
<td>2.4 ± 0.4a</td>
<td>2.5 ± 0.6a</td>
<td>2.7 ± 0.6a</td>
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<tr>
<td><strong>Total gastrointestinal transit time</strong></td>
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<tr>
<td>Plastic pellets</td>
<td>22.9 ± 0.9a</td>
<td>32.8 ± 2.7b</td>
<td>55.1 ± 1.3c</td>
<td>43.2 ± 0.4d</td>
</tr>
</tbody>
</table>

Figure 3: Lateral abdominal radiograph showing the dispersion of markers 8 hours after feeding.

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By decreasing the time for digestion and absorption, a short gastrointestinal emptying time and/or small intestinal transit time could potentially increase the flux of fluids and nutrients entering the colon, which could affect colonic function and consequently fecal moisture and appearance (Guilford & Strombeck, 1996). The gastric emptying time, small intestinal transit time (SITT) and oro-cecal transit time (OCTT) of food were evaluated in our four breeds by using radiopaque markers of 1.5 mm diameter mixed thoroughly with food (figure 3) (Weber et al. 2002b).

No effect of body size on half-gastric emptying time, predictive total gastric emptying time, SITT and OCTT were found (table 1 and figure 4).

However, in this study OCTT was defined as the time when the first marker reached the cecum, and this may not be sensitive enough to detect differences. OCTT has therefore been assessed.
COMMUNICATION

<table>
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<th></th>
<th>MP</th>
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<th>GS</th>
<th>GD</th>
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<tr>
<td><strong>Fecal fermentative products (mmol/kg MS)</strong></td>
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<tr>
<td>Lactic acid</td>
<td>2.0 ± 0.6a</td>
<td>5.0 ± 0.9a</td>
<td>7.1 ± 10.4a</td>
<td>9.1 ± 1.6a</td>
</tr>
<tr>
<td>Total SCFA</td>
<td>448 ± 67a</td>
<td>793 ± 100a</td>
<td>996 ± 61c</td>
<td>1184 ± 259d</td>
</tr>
<tr>
<td>Total dietary fiber digestibility (%)</td>
<td>38.7 ± 4.7a</td>
<td>48.9 ± 3.9a</td>
<td>53.1 ± 2.9b</td>
<td>52.5 ± 4.1b</td>
</tr>
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*Table 2: Effect of size on fermentative sensitivity (Weber et al. 2003a, 2004).* Values (mean±standard deviation) of fecal lactic acid and short-chain fatty acid (SCFA) concentrations (mmol/kg dry matter) and total digestibility of dietary fiber (%) in four dog breeds. T he values with different letters on the same line are significantly different.

These compounds cause an increase in intra-luminal osmotic pressure resulting in considerable water secretion in the colonic lumen, which leads to an increased fecal water content.

The colonic fermentative activity for our dogs was indirectly assessed by quantifying total SCFA and lactic acid in stools and by measuring the total dietary fiber digestibility in the colon (Weber et al. 2004).

Our results showed higher fecal concentrations in lactic acid and total SCFA as well as increased break down of total dietary fiber in GS and GD (table 2). These results suggest greater fermentative activity in these large breeds of dogs. This could contribute to their stools' poor quality and be partly explained by their long colonic transit time.

Clinical studies on humans with diarrhea have revealed an increase in intestinal permeability. (Cooper et al. 1987; Lim et al. 1993). In large dogs, a higher intestinal permeability could also explain the poorer quality of feces.

### Effect of size on intestinal permeability

Intestinal permeability is the property of the epithelium to allow some molecules to be absorbed passively through the mucosa without the assistance of a passive or active biochemical carrier system (Bjarnason et al. 1994). Its increase could cause backflow of absorbed electrolytes into the lumen, which would induce luminal retention of electrolytes as well as water (Guilford & Strombeck, 1996). This phenomenon could lead to increased amounts of fluid entering the colon and an increase in fecal water excretion.

The permeability of the small intestine of the dogs was evaluated by utilizing a differential sugar permeability test using lactulose and rhamnose, respectively a monomer and a dimer, relatively little metabolized after their permeation (Weber et al. 2002a).

Small molecules, such as rhamnose (R), cross the intestinal villi through a transcellular mechanism whereas larger molecules, such as lactulose (L), by an intercellular diffusion (Johnston et al. 2001). The detection of differences in intestinal permeability could be assessed by determining their urinary concentrations L and R and calculating the ratio L/R.

Our results showed a higher ratio of urinary L/R in GS and GD indicating an increased intestinal permeability in these large dogs (figure 5). This could be a cause of their poor digestive tolerance.
The intestinal epithelium usually retains the electrolytes, reabsorbed by active route or by facilitated diffusion, against their concentration gradient. In case of high intestinal permeability, absorbed electrolytes attracted by the concentration gradient return to the intestinal lumen where they accumulate (Guilford & Strombeck, 1996; Gamet 1999). As GS and GD have an increased intestinal permeability, it could be hypothesized that they also have a low net electrolyte absorption.

**Effect of size on net electrolyte absorption**

Water absorption by the intestinal mucosa occurs passively on the basis of a concentration gradient created by electrolyte absorption, more specifically sodium (Pedley & Naftalin, 1993). During its absorption against its concentration gradient, sodium reduces intra-luminal osmotic pressure, drawing water from the intestinal lumen towards the bloodstream by simple diffusion. A low intestinal electrolyte absorption, mainly sodium, may therefore lead to a reduced fluid absorption (Kendrick et al. 2001) and therefore to an increased fecal water content.

The absorption capacity of sodium and potassium was indirectly evaluated in the four dog breeds by calculating the apparent digestibility of these electrolytes and measuring their concentrations in stools (Weber et al. 2004). Our results showed a poorer apparent digestibility of sodium and potassium as well as higher fecal concentrations of these electrolytes in GS and GD, indicating lower overall absorption of these electrolytes in these large dogs compared to small dogs (table 3). This could be explained by their increased intestinal permeability and could contribute to their poor digestive tolerance.

**CONCLUSION**

Results showed no relationship between digestive tolerance of larger dogs and nutrients utilization, absorption capacity or transit time in the upper gastrointestinal tract. However, a low overall absorption of electrolytes as well as an increased fermentative activity could be two possible causes explaining the GS and GD’s poor quality of feces. From these observations, it appears important to limit colonic fermentative activity in large dogs. This could be achieved by firstly using highly digestible diet, which will reduce the quantity of residues arriving in the colon and by secondly reducing the quantity of fermentable fiber in diet.


