Obesity

Use of Ultrasound in the Measurement of Subcutaneous Fat and Prediction of Total Body Fat in Dogs

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ABSTRACT
An ultrasonographic unit (A-scan mode) has been evaluated as a noninvasive method for estimating body fat in 25 dogs. Six anatomical sites were defined and subcutaneous fat thickness was measured by means of ultrasound and histology. Total body fat was subsequently calculated in 12 dogs. There was a high correlation between histology and ultrasound for the measurement of subcutaneous fat (r = 0.81; P < 0.001). Total body fat was successfully predicted using measurements taken with ultrasound at the lumbar area (r = 0.87; P < 0.001). Measurements of subcutaneous fat thickness from other anatomical sites did not estimate body fat with the same accuracy. These results suggest that ultrasound can reliably measure subcutaneous fat in dogs and that these measurements, when taken from the mid lumbar area, can be used to predict total body fat. J. Nutr. 121: S47-S50, 1991.

INDEXING KEY WORDS:
• symposium
• dogs
• subcutaneous fat
• ultrasound
• obesity

Obesity is the most common nutritional disorder in dogs (1-3). In humans, disease problems associated with obesity are becoming increasingly well defined. Coronary heart disease and diabetes mellitus form part of a long list of deleterious effects related to obesity (4, 5). In dogs the consequences of obesity are less well documented and understood. However, there is evidence that canine obesity can be associated with hyperinsulinemia and glucose intolerance (3), decreased resistance to infectious diseases (6, 7), articular and locomotor problems (8), dyspnoea, fatigue and decreased endurance (9, 10), hypertension (11) and increased surgical risk (12).

A major constraint in the investigation of obesity in dogs is the lack of techniques to precisely quantify body fat content. At present, the method of assessing degree of obesity in the dog is to observe and palpate the amount of fat tissue overlaying the rib cage and abdomen. This remains a somewhat subjective estimate (13).

Some of the techniques used in humans for quantifying obesity, such as hydrostatic weighing and fat-soluble gases, are very difficult to apply in dogs. Other methods, such as soft tissue roentgenogram, tritiated water and radioactive potassium, are invasive to the patient. Skinfold calipers, which have been widely used in humans, have not yielded good results in dogs (14). The thickness of the subcutaneous fat layer has been successfully measured in humans by means of ultrasound (15-18). This technique has proved useful for measuring backfat thickness in pigs (19, 20) and cattle (21, 22). This study was designed to evaluate the accuracy of an A-mode ultrasonographic unit in measuring the thickness of the subcutaneous fat layer in dogs and to determine if this measurement was a good predictor of total body fat.

MATERIALS AND METHODS

Twenty-five stray dogs obtained from a charitable organization shortly after the dogs had been killed for humane reasons were studied. Most were mongrel crosses of various sizes. Dogs were classified into one of three age groups: young (between 6 mo and 3 y of age), adult (3-6 y of age) and old (>6 y). The ages and
genders defining this population are summarized in Table 1. Body condition was assessed according to the five-point clinical scale of Edney and Smith [8]. Six anatomical areas were carefully defined on the left side of the carcass and marked with ink.

These were axilla (caudal to the triceps brachii muscle, over the deep pectoral muscle); flank (over the 9th intercostal space, just above the costochondral junction); sternum (1 cm caudal to the xiphoid cartilage and lateral to the linea alba); abdomen (on the left lateral wall of the abdomen, over the obliquus externus muscle); thigh (on the right inner thigh, midway on the diagonal line traced from the ischiatic tuberosity to the lateral condyle of the femur) and lumbar (between the 3rd and 5th lumbar vertebrae, 2–3 cm lateral from the midline).

These areas were clipped and at least five readings were obtained for each anatomical site with the Dermascan-A (Cortex Technology Aps, Denmark). This is an A-mode device employing a focused transducer with a resonant frequency of 20 MHz. All measurements were taken within 1–4 h postmortem and the mean thickness of the subcutaneous fat layer was then calculated for each site.

Immediately after ultrasonic investigation, one biopsy specimen of ~3 x 2 cm was collected from each of the six anatomical sites and was fixed in 10% buffered neutral formalin for 24–48 h. Tissues were then trimmed to 5 mm, processed and embedded in paraffin wax using a V.I.P.-1000 Tissue Processor and a Tissue Tek 2 Embedding system [Miles Laboratories, Stoke Poges, Buckinghamshire, England]. Sections 4-μm thick were cut on a Lietz 1512 rotary microtome [Ernst Leitz Wetzlar GmbH, D-6330 Wetzlar, Germany]. After incubation at 60°C for 30 min, sections were stained by the hematoxilin and eosin method and mounted using D.P.X. mounting medium. The sections were then examined under the microscope and the subcutaneous fat layer measured using a graded lens. A total of six measurements were performed on each section to determine the mean thickness of subcutaneous fat.

Twelve of the 25 dogs were frozen at −20°C after ultrasonic and histologic examination. After freezing, the entire carcass (including viscera) was ground on a whole carcass grinder [Karl Schnell GmBH & Co, 7065 Winterbach, Germany], processed once through a 15-mm plate and once through a 5-mm plate. Two samples each of ~150 g were accurately weighed and sealed inside plastic cups. All samples were then dried to constant weight in a freeze-drier (Edwards High Vacuum, Crawley, West Sussex, England). Two aliquots each of 1 g were ground to pass a 1-mm mesh sieve and placed on dried, preweighed flasks. These were then placed on an extraction thimble and petroleum spirit [boiling range 40–60°C] was used for 6–8 h to extract oil content. After extraction, the flasks were dried and weighed again to determine the amount of fat in the sample.

RESULTS

Subcutaneous fat thickness varied among different animals and body sites (Table 2). The results show the mean thickness of the immediate subcutaneous fat, that is, the layer of fat lying between the dermis and the cutaneous muscle (panniculus carnosus). This layer was usually thickest at the lumbar area.

Ultrasound readings were then correlated with the mean thickness of subcutaneous fat as measured in histology (Fig. 1). There was a good correlation between the two techniques for the measurement of subcutaneous fat (r = 0.81; P < 0.001), and some anatomical areas (namely the lumbar and axilla) showed a better correlation when compared with other body sites (Table 3). In general, histology gave higher readings of subcutaneous fat thickness than ultrasound. This might have been due to the loss of tissue cohesion during processing.

Measurements of fat thickness obtained with ultrasound were utilized to predict body fat (Table 4). Only the axilla and lumbar areas yielded a significant correlation. The measurement of subcutaneous fat that best correlated with total body fat was that taken on the midlumbar area (r = 0.87; P < 0.001). Figure 2 shows the best-fitted straight line for this set of data. The regression equation for estimating body fat in this group of animals, using a single fat measurement was 

\[ Y = 17.48 + 9.77 \times X \]

where Y is the percentage of body fat and X is the mean thickness of subcutaneous fat measured by ultrasound at the lumbar site.

<table>
<thead>
<tr>
<th>Gender</th>
<th>6 mo–3 y</th>
<th>3–6 y</th>
<th>&gt;6 y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>5</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Females</td>
<td>8</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

*Estimated by dentition and wear.*
ESTIMATING BODY FAT IN DOGS

The thickness of subcutaneous fat measured by ultrasound at each anatomical site used in combination with body weight of the animal as predictor variables in the regression equation did not estimate total body fat significantly better than when ultrasound was used as a single predictor.

DISCUSSION

Investigating obesity in dogs and cats has been hampered by the lack of objective techniques to quantify body fat content. Diagnosis of gross obesity does not require great clinical skills. However, when fat deposition is not so obvious, to determine what constitutes obesity and what does not can prove a very difficult challenge. In this study, dogs of approximately the same size and age that had been clinically classified as normal actually showed wide differences in body fat content.

A-mode scanning is the simplest form of ultrasound. It provides a one-dimensional linear array representing the depth between different tissue interfaces. In our study, ultrasound was operating at a frequency of 20 MHz, which was considerably greater than that pre-

TABLE 3

<table>
<thead>
<tr>
<th>Body site</th>
<th>Histology</th>
<th>Ultrasound</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mm</td>
<td>mm</td>
<td></td>
</tr>
<tr>
<td>Axilla</td>
<td>1.59 ± 0.92</td>
<td>1.09 ± 0.42</td>
<td>0.91*</td>
</tr>
<tr>
<td>Flank</td>
<td>1.14 ± 0.57</td>
<td>0.94 ± 0.40</td>
<td>0.73*</td>
</tr>
<tr>
<td>Sternum</td>
<td>1.49 ± 0.84</td>
<td>1.05 ± 0.41</td>
<td>0.77*</td>
</tr>
<tr>
<td>Abdomen</td>
<td>1.33 ± 0.80</td>
<td>1.06 ± 0.49</td>
<td>0.82*</td>
</tr>
<tr>
<td>Thigh</td>
<td>1.27 ± 1.18</td>
<td>1.04 ± 0.53</td>
<td>0.77*</td>
</tr>
<tr>
<td>Lumbar</td>
<td>2.16 ± 1.24</td>
<td>2.12 ± 1.06</td>
<td>0.96*</td>
</tr>
</tbody>
</table>

1 Values are means ± SD of 25 dogs. * P < 0.001.

TABLE 4

<table>
<thead>
<tr>
<th>Body site</th>
<th>Intercept (a)</th>
<th>Slope (b)</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axilla</td>
<td>1.18</td>
<td>39.64</td>
<td>0.62*</td>
</tr>
<tr>
<td>Flank</td>
<td>21.56</td>
<td>19.96</td>
<td>0.46</td>
</tr>
<tr>
<td>Sternum</td>
<td>22.55</td>
<td>16.02</td>
<td>0.48</td>
</tr>
<tr>
<td>Abdomen</td>
<td>26.06</td>
<td>13.60</td>
<td>0.53</td>
</tr>
<tr>
<td>Thigh</td>
<td>45.28</td>
<td>-7.66</td>
<td>-0.17</td>
</tr>
<tr>
<td>Lumbar</td>
<td>17.48</td>
<td>9.77</td>
<td>0.87*</td>
</tr>
</tbody>
</table>

* P < 0.05.
† P < 0.001.

FIGURE 1 Relationship between ultrasonic and histologic measurements of subcutaneous fat thickness at six anatomical locations in 25 dogs.

FIGURE 2 Relationship between ultrasonic measurement of subcutaneous fat thickness at the lumbar area and total fat content in 12 dogs.
viously used in humans (15, 16, 23), pigs (19, 24) and cattle (22) for measuring fat thickness. With our equipment, we were able to measure the layer of fat situated between the dermis and the cutaneous muscle.

We have found considerable variation in the thickness of this fat layer among individuals, although these differences were not so marked among body sites (Table 2). Fat deposition was usually greatest at the lumbar area.

When measurements of subcutaneous fat thickness were used to predict total body fat, we found that only the lumbar measurements were highly correlated to body fat content. In humans, certain anatomical areas give a better prediction of total body fat than others (17, 25), and the same has been found to be true in cattle (26) and horses (27).

Our results suggest that measuring subcutaneous fat thickness in the midlumbar area, between the 3rd and 5th lumbar vertebrae, can be used to predict total body fat in dogs.

ACKNOWLEDGMENTS

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LITERATURE CITED