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PAPER

Dog owner's accuracy measuring different volumes of dry dog food using three different measuring devices

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Abstract

Prior research demonstrates significant inaccuracy when repeatedly measuring the same amount of dry dog food using a dry-food measuring cup, bringing into question the accuracy of measuring devices. This study aimed to determine dog owners' accuracy when measuring different volumes of dry dog food using different types of measuring devices. One hundred dog owners, randomly assigned one of three measuring devices (a one-cup dry-food measuring cup, a two-cup graduated-liquid measuring cup or a two-cup commercial food scoop), were asked to measure ¼, ½ and 1 cup of dry dog food. Accuracy was assessed with an electronic gram scale by comparing measured volumes with the correct weight in grams. Individual accuracy ranged from −47.83% to 152.17% across devices and volumes. Measuring accuracy was found to be associated with the volume of food measured ($p<0.001$) and the type of measuring device used ($p<0.001$). Findings highlight approaches for decreasing excess intake of calories by dogs, including promotion of tactics to improve measurement accuracy (eg, gram scales, volume-calibrated dry-food measuring devices), especially for measuring small volumes.

Introduction

Obesity is considered to be one of the most common medical disorders in dogs.[1] Recent studies have estimated the prevalence of obesity in dogs to range between 34% and 44%, depending on the location of the study and the methods used to assess obesity.[2–5] This high prevalence is concerning due to the negative consequences obesity poses on both the quality and longevity of life in these dogs.[6 7] In addition, obesity increases the risk of numerous medical conditions, including osteoarthritis and hypertension,[8–10] and it can also negatively impact the human–animal bond.[11] As such, obesity is considered an important health and welfare issue. Multiple risk factors have been identified for the development of canine obesity, with excess intake of calories and lack of exercise believed to be the primary contributors.[12]

The majority of pet dogs in developed countries are believed to consume dry dog food diets due to their convenience and value.[13] In addition, the majority of dogs are meal fed specific portion sizes that are believed to be most often measured by pet owners with some form of a measuring cup.[13 14] Prior research, involving the researchers conducting the study and pet nutrition industry associates as subjects, demonstrated significant inaccuracy associated with the use of dry-food measuring cups supplied by pet food manufacturers to measure various amounts of dry dog food. The researchers observed an overestimation in portion size of up to 80% when repeatedly measuring the same amount of dry dog food using the dry-food measuring cups.[14] Consistent overestimation of food portions leads to a potential excess in daily caloric intake, posing an increased risk for obesity over time. As such, the use of kitchen gram scales has been proposed as a more accurate way of measuring a meal of dry dog food and a more accurate way of ensuring the correct daily caloric intake for a dog.[14] The use of an electronic gram scale allows pet owners to measure exact weights of dry dog

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food which corresponds to exact caloric requirements. This is a great benefit for overweight and obese dogs on a weight loss program, and also for the maintenance of weight in lean dogs.

Previous research identifying the inaccuracy of measuring cups for the measurement of dry dog food was limited to one form of measuring device and repeated measures of the same volume.[14] The overall purpose of the study reported here was to use a general population of dog owners to assess the accuracy of various sizes and types of measuring devices for measuring different volumes of dry dog food.

Materials and methods

Participants

During the summer of 2016, a cross-sectional study was conducted, which included recruiting dog owners at various retail store locations, associated with one pet specialty retail chain, in Southwestern Ontario. Participants were also recruited from a public area located in the University Centre at the University of Guelph. Participants were considered eligible if they were 18 years of age or older, owned a dog and fed dry dog food. Participants who fed exclusively canned food to their dogs were excluded.

Questionnaire

A questionnaire was created in two sections and administered using Qualtrics online survey software (Qualtrics, L.L.C., Provo, Utah, USA). The first section was developed to gather demographic information, including participant's gender, age, highest level of education, annual household income, number and type of animal(s) in the household, number of adults in the household and number of children under 18 years of age in the household. Questions about how participants currently fed and measured their dog's food were also asked, including who in the household was primarily responsible for feeding the dog, how many meals a day the dog received and what devices the participants currently used to measure their dog's food. Participants were also asked to indicate which devices they have used to measure their own food. In addition, to characterise the relationship between the participants and their dogs, the first section of the questionnaire included the previously validated Lexington Attachment to Pet Scale (LAPS), a widely used questionnaire for assessing human–animal attachment.[15] Each attachment item was scored on a 4-point Likert scale (4=agree strongly; 3=agree somewhat; 2=disagree somewhat; 1=disagree strongly). An overall attachment score was created as the sum of the 23 items in the LAPS.[15]

The second section of the questionnaire was developed to be used following participant's completion of a dry dog food measuring activity. The second section asked participants, using a visual analogue scale (0, never; 100, always), their likelihood of using the following measuring devices in the future: measuring cup, other cup, scoop, bowl, gram scale or hands for measuring their dog's dry food.

Figure 1 Participants were assigned one of the following measuring devices (from left to right): a two-cup commercial food scoop (Petmate, Arlington, Texas, USA), a two-cup graduated-liquid measuring cup (Betty Crocker; General Mills, Minneapolis, Minnesota, USA) or a one-cup dry-food measuring cup (Polytainers, Toronto, Ontario, Canada), and were asked to measure 1/4, 1/2 and 1 cup of a dry dog food.

Study procedure

Individuals were approached by a research assistant and invited to participate in the study. Participants received an electronic gram scale for their participation. After agreeing to participate in the study and meeting inclusion criteria, participants were asked to complete the first section of the questionnaire. Each participant was assigned to one of three measuring devices. The following measuring devices were rotated sequentially with participant's recruitment: a one-cup dry-food measuring cup (Polytainers, Toronto, Ontario, Canada), a two-cup graduated-liquid measuring cup (Betty Crocker; General Mills, Minneapolis, Minnesota, USA) or a two-cup commercial food scoop (Petmate, Arlington, Texas, USA) (see figure 1). Participants received a short demonstration related to the measurement of the dry dog food, using their assigned measuring device. With their assigned measuring device, participants were asked to measure ¼, ½ and 1 cup of a dry dog food (Royal Canin Size Health Nutrition MEDIUM ADULT dry dog food; Royal Canin, Guelph, Ontario, Canada) (kibble dimension (mm): 15.5×15×7.5) in said order. Accuracy for each respective volume was assessed by weighing out the measured amount with an electronic gram scale (Royal Canin Canada) and comparing the measured volume to the correct weight in grams. The correct weight in grams was determined based on the information provided by the pet food manufacturer for the dry dog food. After having completed measuring all three volumes, participants were asked to complete section 2 of the questionnaire.

Statistical analysis

Descriptive statistics were calculated as frequencies for all categorical variables, and as mean, SE and range for continuous variables. Participants' individual accuracies in measuring were calculated as the percentage difference of the measured volume from the correct volume for each of the three volumes measured. A mixed linear model was used to assess the associations between the volume of food measured and the measuring device used by the participant against the outcome of participant's measurement accuracy. A p value <0.05 was considered significant. Distribution of residuals, and residuals plotted against predicted values, were visually assessed for normality. Normality was also assessed using skew, kurtosis and the Shapiro-Wilk test. Statistical analysis was conducted using SAS V.9.3 (SAS Institute, Cary, North Carolina, USA).

Results

Demographics

A total of 100 participants completed the study protocol. The majority of participants were female (79%; n=79), with 25% between 18 and 29 years of age (n=25). Demographic information for the participants is summarised in table 1. At the time of the study, the majority of participants indicated using a measuring cup for measuring quantity of foods for both their dog (61%) as well as for themselves (73%) (table 2). However, at the time more participants used a gram scale for measuring their own food (20%) as compared with their dog's food (2%). Participants' measuring and feeding practices at the time of the study are summarised in table 2. A mean score of 73.97±0.855 (mean±SEM) was calculated for the LAPS. The range varied from 46 to 89, with the highest possible score being 92. The LAPS score has been previously classified into the following categories of owner to pet attachment: score of 54.9, very attached; score of 44.8, somewhat attached; score of 32.6, not very attached; score of 26.2, not at all attached.[15] Based on these categories, all participants were somewhat attached (n=2) to very attached (n=98) to their dogs.

Measuring accuracy

Participant's inaccuracy ranged from a 47.83% underestimation to a 152.17% overestimation across all measuring devices and volumes (figure 2). Measuring accuracy was found to be associated with the volume of food measured (p<0.001) and the type of measuring device used (p<0.001). Specifically, when accounting for type of measuring device, inaccuracy was greater when measuring a smaller volume of food (eg, ¼ cup compared with 1 cup). When controlling for volume, the one-cup dry-food measuring cup was more accurate as compared with the two-cup graduated-liquid measuring cup and the two-cup commercial food scoop.

Following the measuring activity, participants indicated a mean likelihood of 77.32±3.38 (range 0–100) for using a gram scale for measuring their dog's dry food in the future (figure 3).

Table 1 Demographic information of the 100 dog owners who completed the questionnaire and measuring activity (numerical variations due to missing values)

Variable	%
Gender (n=100)	
Female	79.0
Male	21.0
Age (years, n=100)	
18–29	25.0
30–39	16.0
40–49	19.0
50–59	22.0
60 and older	18.0
Ages of children living in household* (n=93)	
No children	72.0
Child 0–3 years	7.5
Child 4–6 years	4.3
Child 7–12 years	15.1
Child 13–17 years	15.1
Annual household income ($C, n=96)	
Under 10 000	1.0
10 000–19 999	2.1
20 000–39 999	7.3
40 000–59 999	15.6
60 000–79 999	16.7
80 000–99 999	16.7
100 000–119 999	10.4
120 000–139 999	10.4
140 000–159 999	3.1
More than 160 000	16.7
Highest level of education (n=99)	
High school or equivalent	12.1
Vocational or technical school	4.0
Some college or university	12.1
College diploma	18.2
Bachelor's degree	32.3
Master's degree	12.1
Doctoral degree	3.0
Professional degree	5.1
Other	1.0
No of adults living in household† (n=96)	
1	13.5
2	50.0
3	19.8
4	12.5
5 or more	4.2
No and types of animals living in household‡ (n=100)	
Dogs	
1	59.0
2	31.0
3 or more	10.0
Cats	
1	11.0
2	10.0
3 or more	9.0
Other	
1 or more	18.0

*Participants could select more than one option, resulting in an overall percentage greater than 100%.
†Original survey question asked participants to list how many adults lived in the household.
‡Original survey question asked participants to list how many of each animal (dog, cat or other) they owned.

Table 2 Characteristics of 100 dog owners in feeding their dogs, and measuring their dog's food and their own food (numerical variations due to missing values)

Variable	Frequency (%)
Person in household primarily responsible for feeding dog (n=86)	
Participant	80.2
Participant's partner	12.8
Another adult in the household	5.8
Teenager in the household	1.2
A child less than 12 in the household	0
Whether dogs received meals or were free fed* (n=100)	
Meal fed	84.0
Free fed	16.0
Measuring devices currently used for dog's food† (n=100)	
Measuring cup	61.0
Other cup	12.0
Food scoop	17.0
Food bowl	10.0
Gram scale	2.0
Hands	9.0
No device used	2.0
Other	11.0
Measuring devices participants used to measure their own food† (n=99)	
Measuring spoons	50.1
Measuring cups	72.7
Gram scale	20.2
Hands	36.3
Bowls	28.3
Other	8.1

*Original survey question asked participants to list how many meals per day the dog received.
†Participants could select more than one option, resulting in an overall percentage greater than 100%.

Discussion

Using a general population of dog owners, the current study found differences in participants' accuracy when measuring different volumes of dry dog food using various sizes and types of measuring devices. Inaccurate measurement of dog kibble by pet owners can have implications for the general health and wellbeing of their dogs. Consistent underestimation of food could put dogs at risk for severe caloric restriction, leading to nutritional deficiencies. Previous research has found

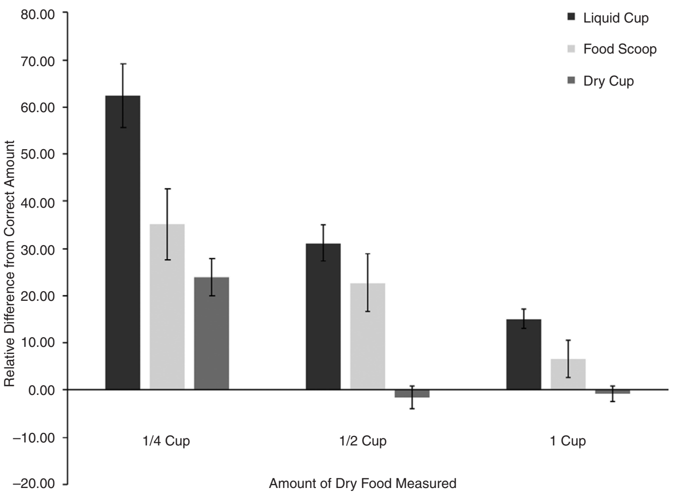

Figure 2 Accuracy of 100 dog owners in measuring 1/4, 1/2 and 1 cup of dry dog food using three different measuring devices (two-cup graduated-liquid measuring cup, two-cup commercial food scoop or one-cup dry-food measuring cup), expressed as relative difference from expected.

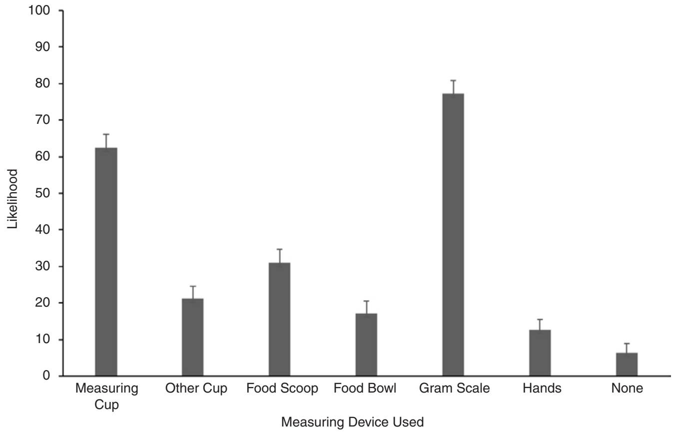

Figure 3 Likelihood from 0 to 100 (0, never; 100, always) of 100 dog owners using certain measuring devices to measure their dog's food after completion of the measuring activity.

choline and selenium to be the nutrients most frequently affected by caloric restriction.[16 17] In comparison, consistent overestimation of food could lead to weight gain, and potentially obesity, in dogs. The accumulation of excess body fat in dogs is associated with increased risk and exacerbation of numerous diseases, including orthopaedic disorders,[8 18] endocrine disorders,[19 20] cardiorespiratory diseases and hypertension,[9 10 21] and neoplasia.[22] In addition to impacting the quality of a dog's life,[23 24] excess body fat can also have negative implications on lifespan. Prior research has demonstrated that lean dogs with an ideal body condition score lived on average two years longer than a control group of overweight dogs.[7] In addition, these lean dogs had delayed developments of chronic diseases, including cancer and osteoarthritis. Although the control group was not obese, this study was able to show the negative effects that even a small amount of excess body fat can have on both morbidity and mortality.[7]

This present study found participants' inaccuracy in measuring dry dog food ranged from a 47% underestimation to a 152% overestimation in the volume of food measured across all devices and volumes measured. These findings support prior research that involved the researchers themselves and pet nutrition industry associates as subjects, which found measuring cups are not an accurate device for measuring dry dog food.[14] The tendency of participating dog owners in the present study to overestimate the volumes of food measured suggests that dogs fed using many of the measuring devices assessed by the present study may provide an excess in daily caloric intake for their dogs, posing an increased risk for weight gain and potentially obesity. In the present study, the greatest inaccuracy in measuring the dry dog food was found when participants were asked to measure the smallest volume (ie, ¼ cup). This has potential implications for small dogs that are likely to receive smaller volumes of dry food, which based on findings of the present study may place them at even greater risk of being overfed if their owner uses a measuring cup or commercial food scoop. By consistently overfeeding a small dog, or similarly a cat, these populations of animals have a higher risk of becoming overweight or obese due to measuring inaccuracy.

An electronic gram scale (ie, measuring by weight not by volume) provides an accurate measurement of dry pet food and, given the results of the present study, is especially important for measuring smaller portions of food. The present study found that 1 in 5 participants already had an electronic gram scale in their home that they had previously used to measure their own food, yet only 1 in 50 reported currently using the gram scale to measure their dog's food. Interestingly, after completing the measuring activity, the majority of pet owners indicated a high likelihood to use a gram scale for measuring their dog's food in the future. Veterinary clinics may benefit their animal patients by demonstrating to pet owners the inaccuracies of different volume-measuring devices and by demonstrating the accuracy of using a gram scale for measuring their pet's dry food. Additionally, the gram scale demonstration reveals to clients the ease by which the gram scale can be used daily. In the authors' experience, this demonstration can be performed routinely by client services staff, veterinary assistants and/or veterinary nurses when a demonstration station is set up permanently in either the waiting room or examination room. Veterinary practices should consider recommending gram scales for all clients to ensure their pets receive appropriate food quantities throughout life and would specifically encourage the promotion of gram scales as a part of all weight loss programmes to ensure food quantities (ie, calorie consumption) are accurate for achieving weight loss.

Recognising participants of the present study, across the three measuring devices, most accurately measured the largest volume of dry dog food (ie, 1 cup), a recommended best practice when using a measuring cup or commercial food scoop would be to advise pet owners to measure an entire day's worth of their pet's food and then divide the daily volume of dry food into the appropriate number of meals and rewards (ie, dry food for training) for their pet. By taking this approach, the pet owner reduces the potential for measurement error by reducing the number of measurement events and, based on findings of the present study, by increasing measurement accuracy associated with larger volumes. It is important to note that once-a-day measurement of a pet's dry food dose by volume using a measuring device is likely not to be as accurate measurement of the pet's dry food quantity using a gram scale. Thus, measuring by weight should be considered the gold standard.

Despite inaccuracies in measurement, many participants also reported a high likelihood of using a measuring cup to measure their dog's dry food going forward. Based on findings of the present study, measuring inaccuracy appears greater when participants used a two-cup graduated-liquid measuring cup, or a commercial food scoop compared with the one-cup dry-food measuring cup. Overall, the least amount of variation across all devices and volumes measured was found when participants were asked to measure 1 cup of dry dog food using the one-cup dry-food measuring cup, followed by participants measuring ½ a cup of dry dog food using the one-cup dry-food measuring cup. This increased accuracy may be due to the decreased room for error in overmeasuring the volume of dry dog food provided by a calibrated one-cup dry-food measuring cup. Therefore, it may be beneficial to advise pet owners, which choose to use a measuring cup, to purchase a dry-food measuring cup that measures as close to the specific volume of food that the animal needs to consume (eg, a quarter-cup dry-food measuring cup for measuring a ¼ cup of dry food).

Participants did receive an electronic gram scale as an incentive for participating in the present study, possibly influencing their indicated intention to use a gram scale for measuring their dog's dry food in the future. Future research should explore whether an incentive, such as a complimentary gram scale, increases an individual's motivation or actual use of a gram scale for measuring their pet's dry food over the gram scale demonstration alone. In addition, observational research examining pet owners' measurement accuracy and actual use of gram scales for measuring pet food in their home environment would be valuable. Furthermore, a number of participating dog owners were not the primary dog feeder in their household. To achieve accurate pet food measurement, it is likely important for veterinary professionals to find out who is feeding the dog and to make sure they are introduced to the importance and how to measure pet food accurately. In addition, this study only investigated the measuring accuracy of dog owners and not specifically cat owners. Given the increased risk that this study found for overestimating feeding amounts for small dogs, further research is necessary to investigate the feeding methods and the possibility for inaccuracy among cat owners.

A limitation of the present study was that the three measuring devices employed were all different in style and size (ie, maximum volume they measure) to represent realistic options available to dog owners. Further research to explore the accuracy of different styles of measuring devices controlling for the maximum volume they can measure is warranted. A second limitation is that the amount of dry dog food participants currently feed their dogs was not measured as part of the present study. Participants' accuracy of measurement may have been influenced by the amount of dry dog food they currently feed their own dog, which should be considered for future research. In addition, the majority of participants in the present study were female and very attached to their dogs, which may have introduced possible selection biases towards women and/or very attached pet owners.

In conclusion, the common overestimation found by the present study in the measurement of dry dog food could be a risk factor for weight gain and potentially obesity in dogs over time. Small dogs were found to be specifically at risk due to the increased inaccuracies of measuring smaller volumes of food. As a result, pet owners should be encouraged to use approaches to the measurement of dry pet food that promote accurate measurement including weighing the food using an electronic gram scale, once-per-day measurement of an animal's daily food quantity or using volume-calibrated dry-food measuring devices.

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Competing interests JBC regularly receives research grants, consults for and receives honoraria from Royal Canin. AR has been employed by Royal Canin as a student-research assistant. TRE receives speaking honoraria from Royal Canin Canada. JMP is employed full time by Royal Canin Canada.

Ethics approval The study protocol was reviewed and approved by the University of Guelph Research Ethics Board (REB no. 16JN002).

Data availability statement All data relevant to the study are included in the article.

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