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## Feline Research

## Pilot study evaluating the effect of feeding method on overall activity of neutered indoor pet cats

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## ABSTRACT

Indoor housing of cats is associated with a higher incidence of multiple diseases, including obesity. Increased exercise is often recommended as a method of creating or increasing the negative energy balance required for weight loss. Food-dispensing toys have been suggested as a method of increasing cat activity and providing environmental enrichment but have not been systematically evaluated in client-owned cats. To compare the effect of meal feeding from a bowl versus a food-dispensing toy on overall activity, 19 client-owned cats were enrolled in a 2-way, 2-period, and randomized repeated-measures mixed-effects crossover study. All cats were acclimated to wearing an accelerometer attached to a collar during week 1. Cats randomized to the bowl-first condition were acclimated to bowl feeding during week 2, and activity counts were collected during week 3. Cats randomized to the toy-first condition were acclimated to toy feeding during week 2, and activity counts were collected during week 3. During week 4, feeding methods were crossed. Cats randomized to the bowl-first condition were acclimated to toy feeding during week 4, and activity counts were collected during week 5. Cats randomized to the toy-first condition were acclimated to bowl feeding during week 4, and activity counts were collected during week 5. The outcome measure of interest was the change in total activity during weeks 3 and 5 for both groups. No significant difference was found in average weekly ( $P = 0.30$ ) or daily activity counts ( $P = 0.17$ ) when cats were fed from a toy compared with a bowl. A treatment effect by day was observed with activity decreasing in the toy-first group and increasing in the bowl-first group between days 3 and 4 ( $P = 0.028$ ). In addition, we found that overall activity of cats decreased 6%–7% with each 1-year increase in age ( $P = 0.041$ ). Although the type of feeding method in this pilot study did not affect overall activity, providing meals to cats using food toys may provide other benefits related to satiety, stress reduction, and overall well-being. More research is needed to explore the benefits of alternative feeding practices for indoor cats.

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## Introduction

A recent survey indicated that an estimated 59% of cats are overweight or obese (Association for Pet Obesity Prevention, 2016), with the number of overweight cats increasing 169% during the

past 10 years (Banfield Pet Hospital, 2017). Obesity is associated with increased occurrence of chronic diseases, such as feline idiopathic cystitis (Lund et al., 2005, 2015) and diabetes mellitus (Fettman et al., 1998; Hoenig et al., 2006; Scarlett et al., 1994). Weight management programs include modifications in food type, caloric intake, and feeding methods (Toll et al., 2010). Increased exercise may also be recommended in an effort to create or increase the negative energy balance required for weight loss (Michel, 2012). In addition, in humans, exercise may play a critical role in prevention of significant weight gain and maintenance of weight loss (Jakicic & Otto, 2005).

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**Table 1**  
Treatment and monitoring schedule for treatment groups

Treatment week	Group B/T	Group T/B
Week 1	Acclimation to activity collar Days 1-2: Collar worn for 2-4 h/d Days 3-4: Collar worn for 6-8 h/d Days 5-6: Collars worn for 12-18 h/d Day 7: Collar worn for 24 h/d <i>Activity counts not collected</i>	Acclimation to activity collar Days 1-2: Collar worn for 2-4 h/d Days 3-4: Collar worn for 6-8 h/d Days 5-6: Collars worn for 12-18 h/d Day 7: Collar worn for 24 h/d <i>Activity counts not collected</i>
Week 2	Cats acclimated to bowl feedings <i>Activity counts not collected</i>	Cats acclimated to food-dispensing toys (Table 2) <i>Activity counts not collected</i>
Week 3	Cats fed from bowl <i>Activity counts recorded</i>	Cats fed exclusively from food-dispensing toys <i>Activity counts recorded</i>
Week 4	Cats acclimated to food-dispensing toys (Table 2) <i>Activity counts not collected</i>	Cats acclimated to bowl feedings <i>Activity counts not collected</i>
Week 5	Cats fed exclusively from food-dispensing toys <i>Activity counts recorded</i>	Cats fed from bowl <i>Activity counts recorded</i>

Indoor cats present a unique challenge to owners who wish to encourage activity as part of a weight management program. Indoor housing of cats is itself associated with an increased incidence of multiple diseases, including obesity (Allan et al., 2000; Robertson, 1999; Scarlett et al., 1994), as well as diabetes mellitus (Slingerland et al., 2009), and feline idiopathic cystitis (Buffington, 2011). Environmental enrichment has long been advocated as part of a multimodal approach to moderating the effects of indoor housing on cats, including stress (Fox et al., 2006), disease (Buffington et al., 2006), and overall welfare (Ellis, 2009).

Some forms of enrichment, including play, may lead to increased activity levels in indoor cats. However, it has been shown that owners of overweight cats play less with their cats than owners of cats in ideal body condition (Kienzle & Bergler, 2006). For these owners, a safe and simple method of increasing activity in indoor cats may assist in compliance with weight management programs. Food-dispensing toys (objects that can hold food and release it after interaction by a cat) have been suggested as such a method (Dantas et al., 2016).

Two studies have explored the effect of multimodal environmental enrichment on weight loss in cats (Clarke et al., 2005; Trippany et al., 2003). These studies used multiple methods to increase cat activity while simultaneously implementing dietary modification to induce weight loss. However, the effect of a single environmental modification on overall activity in cats in the absence of a weight management program has not been assessed. Therefore, the aim of this pilot study was to evaluate the effect of feeding method alone on the overall activity of cats as measured by accelerometry. We hypothesized that use of a food-dispensing toy as the primary feeding method would increase average per-minute daily and weekly activity in cats when compared with bowl feeding.

## Materials and methods

Study participants were recruited from June 2017 to September 2017 via electronic mail and television advertisement. Indoor-only neutered cats who consumed 90% of their daily caloric intake from dry commercial cat food and were fed either 1 meal, 2 meals, or ad libitum throughout the day at the time of enrollment were included. Exclusion criteria included medical conditions influencing mobility or appetite (such as osteoarthritis and renal disease), being routinely fed 3 or more discrete meals per day, and living in multipet households where food could be shared.

All cats received a physical examination, body condition assessment, and an activity collar fitting at enrollment. The activity collar (Actical; Mini-Mitter Co., Inc., Bend, OR) has previously been validated as a surrogate measure of activity and distance moved

(Andrews et al., 2015; Lascelles et al., 2008). Actical monitors were attached to a standard cat collar, worn on the ventral aspect of the neck, and set to collect data (activity counts), as defined by the Actical algorithms, using 1-minute epochs (Lascelles et al., 2008). To avoid behavior changes related to caloric restriction, owners were instructed not to change the diet or amount of food being offered to their pet.

A 2-way, 2-period, and repeated-measures mixed-effects crossover design with a 1-week acclimation period was used. Cats were randomly assigned to 1 of 2 treatment sequences: bowl then toy (B/T) or toy then bowl (T/B). Cats were enrolled in the study for a total of 5 weeks. Table 1 outlines the treatment and monitoring schedule for each group. During week 1, owners were asked to gradually increase the amount of time their cat wore the activity collar each day. After the first week, the collars were worn at all times for the remainder of the study. Cats assigned to the B/T group were acclimated to bowl feeding during week 2, and activity counts were collected during week 3. Cats in the T/B group were acclimated to toy feeding during week 2, and activity counts were collected during week 3. During week 4, feeding methods were crossed. Cats in the B/T group were acclimated to toy feeding during week 4, and activity counts were collected during week 5. Cats assigned to the T/B group were acclimated to bowl feeding during week 4, and activity counts were collected during week 5. All cats were observed during the same number of weekdays and weekends to avoid activity count fluctuations (Gruen et al., 2017).

Table 2 outlines the instructions given to owners in each assigned group. Owners were provided with 2 types of food-dispensing toy systems. Owners performed a subjective trial to determine the toy system their cat preferred to interact with before the beginning of the study. One system was a combination of 5 puzzle toys made by PetSafe (Radio Systems Corporation, Knoxville, TN): Twist 'N Treat™ Teaser Food Dispensing Cat Toy, Egg-Cersizer™, Doorway Dangli™, Fishbowl Feeder™, and SlimCat™ Interactive Feeder. The other system consisted of 5 mouse-shaped toys that hold dry kibble (Doc & Phoebe's Indoor Hunting Feeder™; Doc & Phoebe's Cat Co, Camden, NJ). Once a system of toys was chosen, owners were instructed to place their cat's entire daily ration in toys hidden around the home to mimic hunting behavior. Owners were instructed to use all 5 food-dispensing toys at each meal time. Owners were provided with and signed a consent form stating that they understood the study procedures.

## Statistical analysis

Two separate analyses were performed: 1 for average weekly per-minute activity counts and 1 for average daily per-minute

**Table 2**  
Instructions provided to owners regarding transition and study periods

Treatment week	Group B/T	Group T/B
Week 1	Transition to activity collar	Transition to activity collar
Week 2	Feed regular diet at normal times and quantities in cat's typical food bowl	Acclimate to food-dispensing toy. Dispense cat's daily food ration as follows: approximately 25% from toys/75% from bowl for 2 d, 50% from toys/50% from bowl for 2 d, and 75% from toys/25% from bowl for 2 d
Week 3	Feed regular diet at normal times and quantities in cat's typical food bowl	Place entire daily food ration within toys. Place toys in different areas of the home at typical feeding times to encourage hunting behaviour
Week 4	Acclimate to food-dispensing toy. Dispense cat's daily food ration as follows: approximately 25% from toys/75% from bowl for 2 d, 50% from toys/50% from bowl for 2 d, and 75% from toys/25% from bowl for 2 d	Feed regular diet at normal times and quantities in cat's typical food bowl
Week 5	Place entire daily food ration within toys. Place toys in different areas of the home at typical feeding times to encourage hunting behaviour	Feed regular diet at normal times and quantities in cat's typical food bowl

activity counts. In each case, a mixed-effects crossover design with covariates was performed resulting in an analysis of covariance. Average weekly activity counts were analyzed for treatment (B or T) differences. Average daily counts were analyzed for differences between treatment, time, and for the significance of a treatment by time interaction. Both treatment and time were considered categorical measures. In both cases, age and sex were included as covariates. A categorical period effect was included in both models to measure for the adequacy of washout duration between treatment application sequences. Residuals were analyzed for normality using the Shapiro-Wilk test and for the presence of outliers using box-and-whisker plots. Statistical assumptions for homogeneity of variances were tested using Levene's equality of variances test. After checking model assumptions, it was determined that a log transformation of both daily and weekly activity counts was required to meet the statistical assumptions of each analysis of covariance. SAS, version 9.4 (SAS Institute Inc., Cary, NC), release TS1M3, was used for all analyses.  $P < 0.05$  was considered significant.

## Results

Nineteen domestic shorthair cats (8 spayed females, 11 neutered males; ages 1–12 years with a mean age of 4.6 years [standard deviation {SD}, 2.9]) were enrolled and completed the study. The mean body weight was 5.6 kg (SD, 1.5), and Body Condition Score was 6.1 (SD, 0.9) on a 9-point scale (Lafamme, 1997). Eleven cat owners chose the indoor hunting feeder, whereas the remaining chose the PetSafe toys for the toy treatment period. All cats enrolled in the study were successfully transitioned to the food-dispensing toys and were able to consume their entire typical ration of food exclusively from the toys during that treatment period.

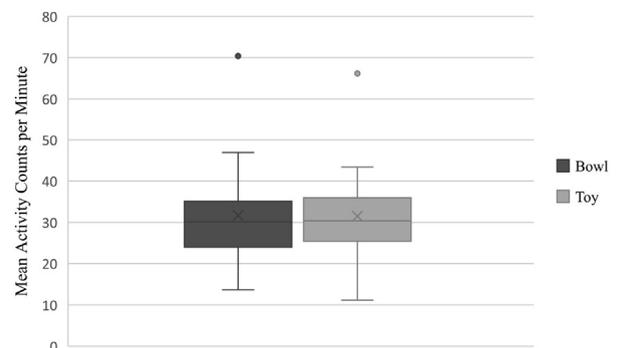
There was no statistical difference in average weekly ( $F = 1.15$ ; degrees of freedom [df] = 1, 17;  $P = 0.30$ ) or daily ( $F = 2.04$ ; df = 1, 17;  $P = 0.17$ ) activity counts when cats were fed from a toy compared with a bowl (Figures 1 and 2). The toy type chosen by individual cats also made no significant difference in outcome Figures 1 and 2. Between days 3 and 4 in our study, average daily activity decreased when cats were fed from toys, whereas activity increased when they were fed from bowls as demonstrated by a significant overall treatment by time interaction ( $F = 2.34$ ; df = 6; 216;  $P = 0.033$ ) (Figure 1). This decrease and increase in activity persisted through the remainder of the treatment periods, although only day 4 was significantly different between treatments ( $t = 2.22$ ; df = 193.8;  $P = 0.0276$ ) (Figure 2). Age influenced overall activity, regardless of treatment, with each yearly increase in age associated with a 6%–7% reduction in daily activity ( $t = -2.23$ ; df = 16;  $P = 0.041$ ) (Figure 3). Overall, observed power of the study was low at approximately 25% for both weekly and daily average treatment activity. However, there was sufficient observed power to evaluate

treatment by day interactions (85%). There were no statistically significant period effects, thereby indicating that the 1-week washout period between treatments was sufficient.

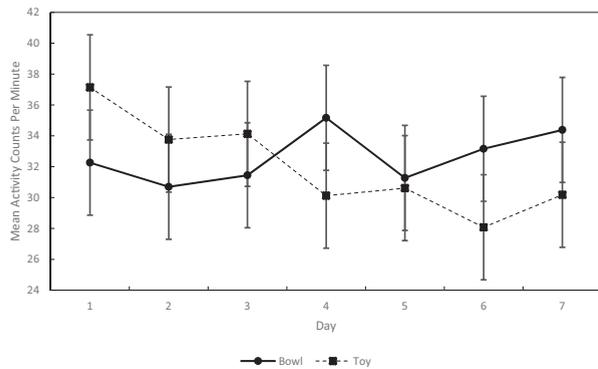
## Discussion

Results of this pilot study suggest that use of a food-dispensing toy as the primary feeding method does not increase average per-minute daily or weekly activity in cats when compared with bowl feeding. A previous report demonstrated that multimodal environmental modification significantly increased the activity counts of cats enrolled in a weight loss program (Trippany et al., 2003). However, those cats were provided with several forms of enrichment, in addition to modifications in their dietary regimen. Multimodal environmental modification may be required to achieve the desired effect of increased activity in these patients. In addition, calorie restriction alone may stimulate more activity and food-seeking behavior. Future investigations measuring activity levels with multimodal environmental modification in the absence of dietary modification would help delineate the effect of multimodal behavior modification compared with any effects attributable to energy restriction. Cats spend most of their time inactive, as measured by a lack of recorded activity counts, making it difficult to detect changes in activity that occur only during a small percentage of minutes in the day. In the original validation study of the Actical Mini Mitter in cats, most activity was recorded for more than only 8% of the total time, and it was during the epochs with activity recorded that eating behavior occurred (Lascelles et al., 2008). Analyzing patterns of activity may be a more appropriate approach for understanding factors affecting cat activity (Gruen et al., 2017).

Previous studies have investigated food anticipatory activity before scheduled meal times (Deng et al., 2014; Godoy et al., 2015).



**Figure 1.** Average total weekly activity calculated from mean activity counts per minute when fed via a bowl or a food-dispensing toy.



**Figure 2.** Average total daily activity calculated from mean activity counts per minute when fed via a bowl or a food-dispensing toy.

Cats fed multiple times daily had increased activity levels before meal feedings when compared with those fed only once daily. In the current investigation, we analyzed overall activity rather than activity for a 2-hour period before each meal. A possible increase in begging behavior before each bowl feeding may contribute to overall activity, negating any increase in overall activity promoted by the food-dispensing toys. Assessment of bowl versus toy food anticipatory activity could determine if the treatment has a significant effect on activity during this shorter period.

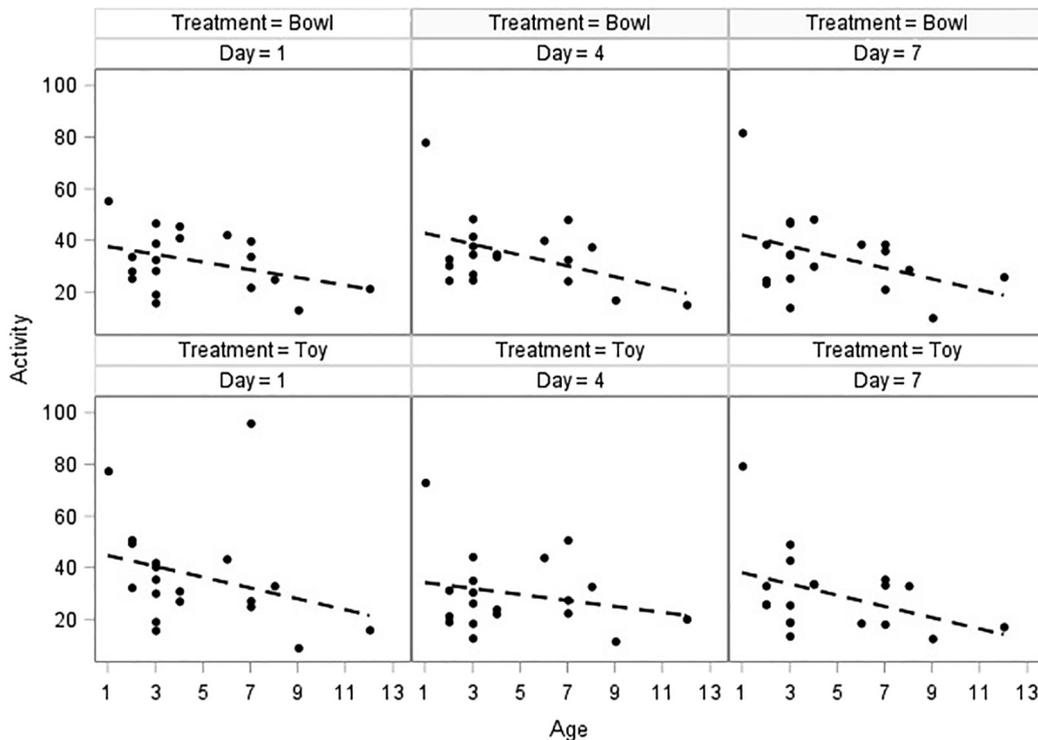
Increasing age was associated with decreasing overall daily activity, regardless of treatment. This result may provide insight into a previous finding that the prevalence of overweight cats and dogs increases with age (Armstrong & Lund, 1996). Decreased activity without proportional decreased caloric intake leads to energy excess and, over time, weight excess (Michel, 2012). A comprehensive weight management program may be considered as patients age to avoid excessive weight gain.

All cats were offered only commercial dry food for the duration of the study. Two recent studies investigated the effect of diet form (dry vs. dry with added water) on voluntary activity in cats (Deng et al., 2014; Godoy et al., 2015). No significant difference in activity was noted between cats fed the dry versus hydrated dry diet. However, a trend toward increased average daily activity level of cats fed a hydrated diet was noted by Deng et al. (2014). Further investigation may be warranted using food puzzles capable of dispensing canned foods to determine if such a combination would result in sustained increases in overall activity.

Godoy et al. (2015) demonstrated that increased feeding frequency (1 meal vs. 4 meals per day) could be an effective strategy in increasing average daily activity in cats. For standardization, owners in our study were instructed to feed cats from the food-dispensing toys as often as they were fed from the bowls. Studies focusing on the effects of combining increased feeding frequency with use of a food-dispensing toy may be warranted.

Although an increase in average activity was not observed in this pilot study, the use of food-dispensing toys may provide environmental enrichment to indoor cats, independent of a change in activity. Anecdotally, the introduction of food-dispensing toys to cats exhibiting undesired behaviors has been associated with decreased aggression toward humans and other cats, reduced anxiety and fear, cessation of attention-seeking behaviors, and resolution of litter box avoidance (Dantas et al., 2016). Level of enrichment was not scored in the present study. Further investigations may seek to analyze such behavioral modifications to determine if a significant association can be observed.

As in all at-home studies, owner compliance may affect results. Owners were not formally interviewed during or after the completion of the study, but no issues were reported to the investigators. Technical concerns that may have affected activity counts include spacing of food-dispensing toys, alterations in meal frequency, changes in diet type, previous pet exposure to



**Figure 3.** Scatter plot comparing age (in years) to activity counts during the analyzed bowl and toy treatment weeks (weeks 3 and 5). For ease of visual interpretation, raw untransformed activity values for days 1, 4, and 7 are displayed. Note that analysis of days 2, 3, 5, and 6 generated similar plots.

food-dispensing toys, or other changes in household routines. Owners were instructed to change only the feeding method during this study, but any additional unreported changes may have resulted in fewer than expected activity counts.

Further investigation may be required to determine if a significant association between food-dispensing toys and increased overall activity exists in a larger sample population. Multimodal enrichment techniques may be required to significantly increase overall daily activity in cats, but this also requires further investigation.

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**Authorship:** All authors have approved the final article. The idea for the article was conceived by Angela Witzel, Julia Albright, and Raju Naik. The experiments were designed by Angela Witzel, Julia Albright, and B. Duncan X. Lascelles. The experiments were performed by Kaitlin Siegfried, Angela Witzel, and Raju Naik. The data were analyzed by Margaret Gruen, Andrea Thomson, Joshua Price, Angela Witzel, B. Duncan X. Lascelles, and Raju Naik. The article was written by Raju Naik and edited by all the authors.

### Ethical considerations

The University of Tennessee—Knoxville Institutional Animal Care and Use Committee approved this study and procedures.

### Conflict of interest

Julia Albright is the PetSafe Chair of Small Animal Behavioral Research at the University of Tennessee. The other authors have no competing interests to declare.

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