Feline Obesity: Food Toys and Owner-Perceived Quality of Life During a Prescribed Weight Loss Plan

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ACADEMIC ABSTRACT

The prevalence of overweight and obesity in the feline population is estimated to be 25.7% and 33.8%, respectively. Feline obesity is associated with comorbidities such as insulin resistance and hepatic lipidosis. Several risk factors are associated with obesity including middle age, neuter status, decreased activity, and diet. Obesity management is multifaceted and includes client education, diet modification, and consistent monitoring. Successful obesity management may be dependent on owner perception of their cat's quality of life during a prescribed weight loss plan. Low perceived quality of life may result in failure to complete the weight loss process. Food toys may be used to enhance environmental enrichment, allow cats to express their natural predatory behavior and overall improve owner-perceived quality of life. Therefore, we set out to investigate the role of food toys in owner-perceived quality of life of obese cats during a prescribed weight loss plan.

Fifty-five cats with a BCS $\geq$ 7 were enrolled in a double-blinded weight loss study and randomized into one of two groups: food toy (n=26) or food bowl (n=29). Each cat was provided a prescribed weight loss diet and instructions. Body weight and body condition score were evaluated monthly. Additionally, owners completed a monthly questionnaire to assess their cat's quality of life.

Of the 44 cats in the final analysis, 66% (n=29) successfully completed the study and lost $\geq$ 2 BCS points and/or achieved an ideal BCS of 5/9. Low-calorie vegetables were offered to the majority of cats (n= 32) due to owner reports of disruptive food seeking

behavior. Of the cats offered vegetables, 87.5% (n=28) cats required a commercial palatant to consume the vegetables. All enrolled cats had a higher ($p<0.0000$) owner-perceive quality of life at the final visit/recheck/end of study (median QOL=110.0), as compared to the initial weight loss appointment (median QOL=126.0). The increase in quality of life was primarily driven by improvement in moving from one place to another, grooming and scratching, engaging in social activities, and playing and hunting. There was no effect ($p=0.27$) of food toy on owner-perceived quality of life.

Prescribed weight loss improves owner-perceived quality of life of obese cats. A single food toy (ball-style) was included in this study and did not appear to influence owner-perceived QOL. However, the role of food toys needs further investigation as there are several food toy styles that have not yet been investigated during a prescribed weight loss plan. We suspect that most/all of the 32 cats fed vegetables would have withdrawn from the study. Therefore, including vegetables in the prescribed weight loss plan appears to improve success of weight loss in obese cats.

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GENERAL AUDIENCE ABSTRACT

About 60% of cats are overweight or obese, which equates to about 56 million cats in the United States. Feline obesity is associated with poor health outcomes such as insulin resistance and fatty liver disease. Risk factors for feline obesity include middle age, neutered, decreased activity, and diet. Obesity is commonly diagnosed via body condition scoring in small companion animals. Owner-perceived quality of life is an important factor for a successful weight loss plan. Low perceived quality of life may result in owners abandoning the weight loss process. Food toys provide environmental enrichment, slow food consumption and may increase activity. However, the impact of food toys on owner-perceived quality of life and the success of a weight loss plan were not previously investigated.

Fifty-five cats were enrolled into the weight loss study and randomly placed into one of two groups. Twenty-six cats were placed in the food toy group, and 29 cats were placed in the food bowl group. Monthly follow-up visits consisted of weighing and body condition scoring each cat. In addition, owners completed a questionnaire to evaluate their cat's quality of life. Food toys did not influence cat owner perception of their cat's quality of life. However, cat owners perceived their cat's quality of life to be higher at the

end of the study compared to the beginning for all cats. The increase in quality of life was primarily driven by improvement in moving from one place to another, grooming and scratching, engaging in social activities, and playing and hunting. Satiety was an issue for several cats during the study. Low-calorie vegetables were offered to over half of the study cats to decrease hunger and food-seeking behavior. This study indicates quality of life is increased in cats undergoing a prescribed weight loss plan. A single food toy was utilized in the present study although several types of food toys are currently available that have not been investigated in relation to owner-perceived quality of life during a prescribed weight loss plan.

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ATTRIBUTES

The research and writing associated with this manuscript would not have been possible without aid from colleagues. Contributions are defined below.

Megan Shepherd, DVM, DACVN, PhD, is an Assistant Professor of Nutrition at the Virginia-Maryland College of Veterinary Medicine. Dr. Shepherd was integral to the study idea and design, aided in data collection, and contributed to the manuscript preparation.

Stephen R. Werre, PhD a Research Assistant Professor of Veterinary Medicine Experimental Statistics at the Virginia-Maryland College of Veterinary Medicine. Dr. Werre helped performed statistical analysis on all study data and provided data interpretation.

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ABBREVIATIONS

DXA	Dual-energy X-ray absorptiometry
BCS	Body condition score
MCS	Muscle condition score
OTC	Over the Counter
VTWD	Veterinary therapeutic weight loss diet

CHAPTER 1: INTRODUCTION

This thesis is compiled to examine the current understanding and management of feline obesity. The following literature review is focused on the prevalence, diagnosis, risk factors, comorbidities, and management of obesity as discussed in the veterinary literature. A single manuscript is incorporated, which will be submitted for publication. The following manuscript discusses owner perceived cat quality of life during a prescribed weight loss plan.

CHAPTER 2: LITERATURE REVIEW

Obesity refers to the excessive accumulation of adipose tissue that adversely affects health (Dottie P. Laflamme, 2006). In general, obesity is a consequence of long-term positive energy balance that results from excessive energy intake in relation to energy expenditure leading to an increase in energy storage (Chandler et al., 2017; Hill, 2006; Mennella, 2019).

2.1 Consequences of Obesity

Obesity, excessive accumulation of white adipose tissue, has various consequences in the feline population including metabolic, mechanical, diagnostic consequences, and possibly reduced lifespan (German, 2006; Tarkosova, Story, Rand, & Svoboda, 2016). Obesity is a major factor in the development of insulin dysregulation (Appleton, Rand, & Sunvold, 2001; Blouin, 2012). Sixteen research cats were fed high energy diets ad libitum to promote weight gain (Appleton et al., 2001). Cats had an average weight gain of 1.91kg; six were considered overweight and ten became obese based on a five-point body condition scoring (BCS) system. Weight increased 44% over 10 months, and insulin sensitivity was reduced by 52% on average (Appleton et al., 2001). Hoenig, Thomaseth, Waldron, and Ferguson (2007) reported an approximate 30% loss in insulin sensitivity with each kilogram increase in weight. Reduced insulin sensitivity results in a higher insulin concentration needed for glucose uptake. Compensatory hyperinsulinemia results to maintain blood glucose. When this occurs for a sustained period of time, pancreatic beta cells, which synthesize and secrete insulin to promote uptake of glucose by peripheral tissues, becomes over worked leading to type 2 diabetes mellitus.

Hepatic lipidosis, or fatty liver disease, is a severe potentially life-threatening condition characterized by accumulation of triglycerides in the liver leading to liver dysfunction (Ibrahim, Bailey, Sunvold, & Bruckner, 2003). Overweight cats have higher concentrations of hepatic fat and the concentration of fat increases significantly post weight loss compared to lean cats (Ibrahim et al., 2003). Although the etiology is not fully understood, obesity has been shown to be a risk factor for hepatic lipidosis (Center, 2005; German, 2006). In many cases, affected cats have an underlying disorder causing anorexia and/or rapid weight loss and overweight/obesity can increase the risk for hepatic lipidosis. This is important when implementing a weight loss plan in cats. Cats should be monitored consistently when undergoing a weight loss plan to ensure they are losing at an appropriate rate to decrease the chance of inducing hepatic lipidosis.

Pulmonary function has been shown to become compromised as a result of obesity by decreasing pulmonary and total chest compliance (Garcia-Guasch et al., 2015). Pulmonary function variable between six obese cats were compared to nine cats of ideal weight through barometric whole-body plethysmography, a non-invasive pulmonary test. Obese cats had significantly lower tidal volume per kilogram, minute volume per kilogram, and peak inspiratory and expiratory flows per kilogram (Garcia-Guasch et al., 2015).

Obesity has been shown to be a risk factor for orthopedic disease in dogs and humans (Adams, Bolus, Middleton, Moores, & Grierson, 2011; Kealy et al., 1997; Kealy et al., 2002). Obesity may be a risk factor for orthopedic disease in cats as well; however, cats may be less likely to be diagnosed with orthopedic disease due to their nature. Cats may be more likely to rest if suffering orthopedic disease and, unlike dogs, are less likely to be

taken for walks or to the park; therefore, clinical signs may not be obvious to owners (German & Martin, 2008). Joint disease can affect a cat's gait, ability to jump, and play which can decrease QOL.

Overweight and obesity may affect longevity in cats as well. Studies in humans and dogs have shown increased adiposity if associated with decreased life expectancy (Kealy et al., 2002; Prospective Studies et al., 2009; Salt, Morris, Wilson, Lund, & German, 2019). A long-term prospective study regarding cause-specific mortality utilizing 894,576 human participants indicated a BMI above the ideal range (22.5-25kgs/m^2) is a strong predictor of overall mortality (Prospective Studies et al., 2009). Median survival in humans was decreased by two to four years at a BMI of 30-35kg/m^2 while median survival time was decreased by eight to ten years at a BMI of 40-45kg/m^2 (Prospective Studies et al., 2009). A lifelong study of 48 Labrador Retrievers from seven litters utilized a pair feeding method beginning at eight weeks of age until death (Kealy et al., 2002). In each coupling, 1 dog was fed 25% less than their pair-mate (Kealy et al., 2002). The restricted feeding group had a mean body weight that was on average 26% lower than their counter parts in the controlled feeding group. In addition, the median survival time was significantly less in the controlled feeding group compared to the restricted feeding group (11.2 years vs.13 years).

Epidemiological data has shown obese cats have a higher risk for developing urinary tract disease, dermatological disease, neoplasia, and oral cavity disease (Lund, Armstrong, Kirk, & Klausner, 2005). Dermatological conditions may be related to difficulty grooming and morbidly obese cats may develop pressure sores due to inactivity (German & Martin, 2008). Lund et al. (2005) indicated adenocarcinoma, basal cell carcinoma,

fibrosarcoma, lipoma, lymphosarcoma, mammary tumor, mast cell tumor, squamous cell carcinoma, tumor-unspecified were the types of neoplasia more commonly diagnosed in obese cats. Oral diseases more commonly diagnosed include cervical lesions, dental caries, dental calculus, dental calculus/gingivitis, fractured tooth, gingivitis, periodontal disease, ptyalism, stomatitis (Lund et al., 2005). Further studies need to be performed to understand the association between obesity and these diseases.

Obesity does not just impact everyday life but also diagnostic and treatment procedures as well. Clinically, obesity impairs routine evaluations and other diagnostic techniques such physical examination, abdominal palpation, thoracic auscultation, lymph node palpation and aspiration, drawing blood, cystocentesis, ultrasonography and other imaging modalities (German, 2006). Furthermore, excessive adiposity may increase time of surgical procedures and affect drug dosing which may increase anesthetic risk (Barras & Legg, 2017; German, 2006). Feline obesity not only has clinical implications but financial and possibly emotional implications as well. Banfield Pet Hospital reported 36% more money is spent on diagnostic procedures for overweight cats compared to cats of ideal body weight and an estimated additional $1,178 is spent per year on obesity-related issues in cat (*Banfield Pet Hospital State of Pet Health Report*, 2018). The financial implications of obesity may lead to unnecessary stress in pet owners. Pets are important family members and friends (Blouin, 2012); therefore, the resulting comorbidities associated with obesity may not only serve as a source of financial stress but emotional stress as well.

2.2 Prevalence of Feline Obesity

Prevalence data concerning feline overweight and obesity is important in understanding the extent to which overweight and obesity occurs and trends overtime to improve treatment of feline patients. There is limited data regarding the prevalence of overweight and obesity in cats with most of studies concentrated in Europe, Australia, New Zealand, and the United States. A wide range of prevalence data exist regarding feline overweight and obesity. When comparing the high end of each country's overweight/obesity prevalence range, the United States had the highest prevalence (17-59.5%) followed by Japan (56%), Netherlands (51%), United Kingdom (6-52%), Denmark (41%), New Zealand (24.5-27.4%), France (27%), and lastly Australia (18.9-26.2%) having the lowest prevalence. The earliest USA study reported a 17% prevalence rate for data collected between 1986-1988 and increased to 59.5% by 2018. This is in line with increasing trends in overweight and obesity reported by Banfield, a large veterinary hospital company who indicated a 169% increase in overweight and obesity between 2007 and 2016 (*Banfield Pet Hospital State of Pet Health Report*, 2018). New Zealand has not experienced such an increase in overweight and obesity prevalence, but instead as remained relatively constant from 2000-2007 (28.8% vs. 27.4%). Overall, the prevalence of overweight and obesity is reported to range from 11.5%-59.5% worldwide per data collected within the last ten years.

Various hypotheses have suggested the discrepancy in prevalence may be a result of sampling, geographical location, methodology, or responses may differ depending on who is surveyed e.g. owners versus veterinarians (Russell, Sabin, Holt, Bradley, & Harper, 2000; Sandøe, Palmer, Corr, Astrup, & Bjørnvad, 2014). Courcier, Mellor,

Pendlebury, Evans, and Yam (2012) estimated a lower prevalence of obesity compared to previous studies performed in the UK (Courcier, O'Higgins, Mellor, & Yam, 2010; Russell et al., 2000). This may be attributed to the differences in data collection e.g. primary versus secondary data (Courcier et al., 2012). Prevalence may differ due to differences in how overweight and obesity are classified. Level of training may also affect BCS (Shoveller, DiGennaro, Lanman, & Spangler, 2014). BCS is a subjective assessment allowing for potential inter- and intra-evaluator variation. If not performed properly, an inappropriate body condition may be reported resulting in misdiagnosis. Furthermore, scoring may potentially be confounded by breed disposition e.g. leaner versus stockier breeds. Studies such as Lund et al. (2005) utilized a consistent BCS training method to educate veterinarians in various practices on how to properly BCS. Courcier et al. (2012) utilized retrospective data from multiple clinics that did not undergo such a training. Sampling also differed amongst studies. I. Robertson (1999) Kronfeld, Donoghue, and Glickman (1994) sampled cats visiting a referral veterinary teaching hospital for various reasons, compared to Colliard, Paragon, Lemuet, Benet, and Blanchard (2009) who sampled cats specifically visiting the Vaccination Department of different veterinary teaching hospital. Cats visiting referral veterinary teaching clinics may be thinner due to concomitant disease while cats visiting a vaccination department are possibly more likely to be healthy. In addition, Cave, Allan, Schokkenbroek, Metekohy, and Pfeiffer (2012) and Allan, Pfeiffer, Jones, Esslemont, and Wiseman (2000) sampled cats in domestic homes. Mori, Iwasaki, Okada, Kawasumi, and Arai (2016) sampled only healthy cats in a clinical setting, while Courcier et al. (2010) studied cats visiting a primary care veterinary clinic but did not specify health status as

part of the inclusion criteria. Again, the sampling frame may confound study results and result in a wide discrepancy. Lund et al. (2005) indicated that region was not a risk factor for overweight and obesity which may indicate similarities across the United States, but this cannot be fully elucidated because housing accommodations and other lifestyle indicators were not collected. Urban areas may have a higher rate of feline obesity as result of indoor living compared to a rural area where cats may have greater access to the outdoors and ample opportunities for exercise. In addition, over-humanization of cats has been associated with increased adiposity (Kienzle & Bergler, 2006). Urban indoor cats may be more likely to have a closer relationship with their owners compared to rural cats who may have been acquired as a 'working cat' e.g. rodent control.

Reference	**Year of Data Collection**	**Country**	**Sample Size**	**Sample Location**	**Evaluator of body condition**	**Criteria**	**% of cohort overweight + obese**
Kronfeld et al., 1994	1986-1988	USA	1620	1 veterinary clinic (university)	Veterinarian	5-point BCS	17% (16% overweight, 1% obese)
Scarlett et al., 1994	Not stated	USA	>2000	31 veterinary clinics	Veterinarian Owner	6 cat shape silhouettes	25% (20% overweight, 5% obese*)
Lund et al., 2005	1995	USA	8,159	52 Veterinary clinics	Veterinarian	5-point BCS	29.1% (28.7% overweight, 6.4% obese)
Association for Pet Obesity Prevention, 2018	2018	USA	646	146 veterinary clinics across 41 states	Veterinarians	9-point scale	59.5% (25.7% overweight, 33.8% obese)
Russell et al., 2000	Not stated	UK	136	Domestic	Trained evaluator	17-point BCS (9-point scale incorporating 1/2 -point increments)	52% (48% overweight, 4% obese)

Courcier et al. 2010	2008	UK	118	1 veterinary clinic	Veterinary student, owners	5-point BCS	39% (28.8% overweight, 10.2% obese)
Courcier et al., 2012	2008-2010	UK	3219	47 veterinary clinics	Veterinarian	5-point BCS	11.5% (9.7% overweight, 1.8% obese)
Allan et al 2000	1993	New Zealand	202	Domestic	Experienced evaluator, owner	5-point scale	25.8% (23.1% overweight, 2.7%, extremely overweight*)
Cave et al., 2012	2007	New Zealand	200	Domestic homes	Veterinarian, owner	Owner: 5-point Veterinarian: 9-point BCS	27.4% overweight, obese
Gates et al., 2019	2011-2016	New Zealand	23,794	10 veterinary clinics	Veterinarian	9-point scale	24.5% (21.9%overweight, 2.6% obese)
Robertson, 1999	1996	Australia	644	458 Domestic homes	Owners	3 categories (underweight, correct weight, overweight)	18.9% overweight, obese
McGreevy et al., 2008	2000	Australia	1042	48 veterinary clinics	Veterinarian	5-point BCS	26.2% overweight, 6.6% obese
Sloth, 1992	Not stated	Denmark	223	1 veterinary clinic	Veterinarian	Not stated	41% (27.8% overweight, 12.7% obese)
Colliard et al., 2008	2006	France	385	1 Veterinary clinic (university)	Veterinarian, owner	5-point BCS	27% (19% overweight, 7.8% obese)
Corbee et al., 2014	Not stated	Netherlands	268	2 cat shows	Veterinarian	9-point BCS	51% (41% Overweight, 4.5% obese)
Nobuko et al., 2016	2008-2013	Japan	190	18 veterinary clinics	Veterinarian	5-point scale	56% (14% overweight, 42% obese)

Table 2.1: Prevalence of Feline Obesity

2. Risk Factors for Obesity

Obesity is generally a result of chronic positive energy balance; however, there are numerous factors that interplay to determine weight and body condition. In humans, body

weight has been described as the result of the "interaction between genetic, environmental and psychosocial factors acting through the physiological mediators of energy intake and expenditure" (Kopelman, 2000). Many of the same factors that increase the risk for obesity in the human population, have been associated with obesity in domestic cats. Risk factors associated with feline obesity include age, sex, neuter status, breed, environment, activity, diet, and owner perceptions and behavior.

2.3.1 Signalment

Multiple studies have associated age as a risk factor for increased adiposity with a higher prevalence of overweight/obesity previously being reported in middle-aged cats (German, 2006; Dottie P. Laflamme, 2006). Courcier et al. (2012) reported a higher prevalence of obesity in prime and mature life stages (3-10 years of age). These findings are similar to previous studies where 40% of cats age 5-11 years old were overweight or obese (Lund et al., 2005). For cats aged 2-9 years of age, age was a positive risk factor for obesity (Colliard et al., 2009). Furthermore, Sloth (1992) indicated 60% of cats greater than three years of age were overweight or obese compared to only 14% of cats less than three years of age in a survey of cats presented to a single small animal clinic. This may be a result of decreased physical activity as cats age (Dottie P. Laflamme, 2006).

Epidemiological studies have indicated male cats are more likely to be obese than female cats (Colliard et al., 2009; Corbee, 2014; Lund et al., 2005; Öhlund, Palmgren, & Holst, 2018; I. Robertson, 1999). I. Robertson (1999) speculates owners may be more likely to classify male cats as above ideal due their generally larger frames than females. This is in contrast to reports of owners tending to underestimate their cats BCS (Colliard et al.,

2009; Courcier et al., 2010). Neuter status, regardless of sex, has been associated with overweight and obesity with neutered male cats having a higher prevalence of being overweight compared to intact males and intact/spayed females (Colliard et al., 2009; Courcier et al., 2012; Courcier et al., 2010; Larsen, 2017; Lund et al., 2005; I. Robertson, 1999; Russell et al., 2000; Sloth, 1992). Fettman et al. (1997) compared neutered and entire male and female cats prior to gonadectomy, at one month, and three months post-surgery. Although weight increased significantly in all groups, altered males (4.63kg [mean weight before gonadectomy], 5.43kg [mean weight one month after surgery], 5.97kgs [mean weight 3 months after surgery]) and altered females (2.59kg, 3.15kg, 3.60kg) gained significantly more body weight and body fat compared to intact males (5.20kg, 5.73kg, 5.82kg) and females (2.94kg, 3.31kg, 3.41kg) (Fettman et al., 1997). Higher body condition scores has also been noted in neutered feral cats. Adult feral cats were trapped and evaluated prior to neutering; 54% of cats were considered lean with a BCS less than five and 8% had a BCS greater than or equal to five on a nine-point scale (Scott, Levy, Gorman, & Newell, 2002). One-year post gonadectomy, mean body weight increased by 40% (3.1 vs. 3.8kg). Only 14% of cats had a BCS less than 5 while 71% had a BCS greater than five. The follow-up evaluation also indicated decreased roaming post-surgery. A decline in physical activity may explain increased body weight and body condition score (Scott et al., 2002).

Other studies implicated increase in food intake rather than decreased energy expenditure as the cause for increased weight gain (Kanchuk, Backus, Calvert, Morris, & Rogers, 2003; Wei et al., 2014). In one study, food intake increased at three months post-gonadectomy (mean intake of 57.7g/day [before gonadectomy] vs. 72.8g/ day [three

months after gonadectomy] for neutered males; 44.3g/day vs. 52g/day in spayed females), but remained relatively constant in intact cats (57.8g/day vs. 55.3g/day for males; 53.1g/day vs. 53.8g/day for females) (Fettman et al., 1997). Alexander, Salt, Thomas, and Butterwick (2011) reported a 17% higher feed intake in neutered female kittens, as compared to intact littermates (Alexander et al., 2011). Food intake in neutered kittens was highest 10-weeks post-surgery and then decreased to no significant difference between neutered and intact kittens 18 weeks after surgery (Alexander et al., 2011). Regardless of the decline in food consumption 18 weeks post-surgery, mean body weight (4.1kg v. 3.2kg) and BCS (6.1 v. 5.2) were significantly higher in neutered kittens compared to intact kittens by one year of age (Alexander et al., 2011). Thus, food consumption may not be the only variable associated with obesity in cats.

Breed may be a risk factor for obesity as well. Epidemiological data suggest obesity is more prevalent in domestic shorthair, medium hair, longhair, and Manx breeds (Lund et al., 2005). Furthermore, I. Robertson (1999) reported mixed-breed cats were significantly more likely to be obese. Half of show cats were reported to be overweight (45.5% BCS>3/5) or obese (4.5% BCS >4/5) and indicated a significant difference in BCS between breeds (Corbee, 2014). Breeds associated with a significantly higher BCS relative to the average BCS (5.55) of all show cats were the British Shorthair (5.92), Norwegian Forest Cat (5.86), and Persians (6.27) compared to Abyssinian (4.43), Cornish Rex (4.40), Devon Rex (4.60), Oriental Shorthair (4.67), and Sphynx (4.40) which had significantly lower BCS relative to the average BCS of the show cats (Corbee, 2014). In contrast, Colliard et al. (2009) reported Persian cats had a lower risk of obesity.

However, there is not a consensus among studies regarding association between obesity and breed (Courcier et al., 2012; Courcier et al., 2010).

2.3.2 Diet

Dietary factors including what and how the diet is fed are important risk factors for obesity. Allan et al. (2000) acquired diet, health, and behavior information of 202 cats to study risk factors associated with obesity in cats. Fresh meat and/or fish was identified as a risk factor for obesity. Although the amount of fresh meat and/or fish fed was not obtained, the increased palatability may drive increased food consumption; thus, increased caloric intake (Allan et al., 2000). Kienzle and Bergler (2006) reported similar findings upon interviewing 60 cat owners with overweight cats and 60 owners with cats of ideal weight. Overweight cats were offered fresh meat, kitchen scraps, or other treats in addition to their regular diet more often compared to cats of ideal weight (Kienzle & Bergler, 2006). Similar to Allan et al. (2000), the amount of these foods offered was not explored.

Lund et al. (2005) performed an epidemiological study utilizing the data collected on 8,159 adult cats. In this study, the risk of obesity varied by food type. Premium diets, defined by Lund et al. (2005) as "brands typically purchased in a veterinary practice, pet store, or large-format pet retailer" and therapeutic diets, defined as "brands prescribed and sold by veterinarians for the treatment or prevention of disease", were significantly associated with overweight/ obesity. Compared to diets purchased at grocery stores and farm stores, premium foods may contain a higher energy density and the amount and/or rate at which these foods are fed may provide more than the needed calories to maintain

ideal BCS (Lund et al., 2005). The justification for feeding veterinary/prescription diets wasn't disclosed; there may have been more obese cats in the veterinary/prescription group because they were on a prescribed weight loss plan (Lund et al., 2005).

The dynamic of ad libitum vs. meal feeding appears to influence the risk of obesity, at least in some studies. Courcier et al. (2010) surveyed cat owners and reported cats fed twice daily were four times more likely to be overweight or obese compared to cats offered food ad libitum. This is in contrast to Harper, Stack, Watson, and Moxham (2001) who reported higher weight gain in post ovariohysterectomy cats fed ad lib (31% increase), as compared to control fed cats (7.5% increase) and Kienzle and Bergler (2006) who indicated 60% of cats of ideal weight were free choice compared to 83% of overweight cats being fed free-choice.

Not all investigators find an impact of feeding frequency on risk of overweight and obesity in cats (Allan et al., 2000; Colliard et al., 2009; Donoghue & Scarlett, 1998). In a United Kingdom study, there appeared to be an interaction between feeding frequency and food type on risk of overweight and obesity. Cats fed canned food ad libitum had a significantly higher mean BCS compared to cats meal fed canned food (Russell et al., 2000). In the same study, BCS was higher for those fed ad libitum kibble vs. meal fed kibble but this was not significant. Russell et al. (2000) indicated this may be a result of the United Kingdom having a predominantly canned cat food-based market. The discrepancy regarding the significance of feeding frequency and obesity has been attributed to questionnaire wording. For example, owners may have not understood the definition of self-choice, meaning weighed amount of food per day and ad-libitum, meaning having food always available (Colliard et al., 2009; Courcier et al., 2010).

2.3.3 Behavior and Perception

Owner behavior is a major risk factor for obesity because owners manage their cat's diet. Offering food may be a how owners show affection toward their cat, but feeding in excess of caloric needs puts their cat at risk of obesity. As stated previously, offering cats foods outside of their primary diet, such as table scraps has been associated with obesity as well.

Owner-perception of their cat's weight is a risk factor for obesity because perception can guide behavior. Owners of cats with an ideal BCS perceived their cats to initiate play more often than owners of overweight cats (78% of owners versus 58%) and indicated playing with their cat as more important to them as well (Kienzle & Bergler, 2006). Furthermore, owners of ideal weight cats perceived their ability to play with their cat as an advantage of cat ownership significantly more than owners of overweight cats. Thus, owners of cats at ideal weight spent more time engaging in play activities with their cats. Owners of overweight cats more often utilize food rather than play as a method of treating, were more likely to provide their cat with their favorite dish, offer food as result of begging behavior, and were more likely to watch their cat as they ate compared to owners of cats with an ideal BCS (Kienzle & Bergler, 2006). This may indicate the "food is love culture" extends to household cats and that offering food items is perceived as an important factor in the human-animal bond. Various studies have indicated owners tend to underestimate their cats BCS (Allan et al., 2000; Cave et al., 2012; Colliard et al., 2009; Courcier et al., 2010). Owners who have a false perception of their cat's BCS may

be in denial when their cat is diagnosed with overweight/obesity and therefore less likely to seek out assistance regarding overweight/obesity management.

Not only owner-perception, but veterinarian's perception of overweight and obesity may be a risk factor as well. Underreporting of obesity as a diagnosis by veterinarians was reported as a common occurrence. Only 2.2% of cats were diagnosed as being obese although 6.4% of cats were considered obese via BCS (Lund et al., 2005). Underdiagnosing was even more profound in overweight cats with only 1.4% of overweight cats reportedly diagnosed as overweight compared to 28.7% of cats considered overweight via BCS. This may indicate that some veterinarians may not perceive overweight and obesity as a disease (Lund et al., 2005).

Breed perception as provide by breed standards, per the American Cat Franciers Association, may play a role in obesity as well. Breeds associated with obesity were described as chubby, sturdy, broad chested, considerable girth, large and imposing (males), having full cheeks, well-rounded contours, bull-neck and cobby (short, thick, stocky) (Corbee, 2014). Owners of such breeds, especially those of show cats, are probably more likely to adhere to these descriptors to meet breed standards and judge's expectations. Because these descriptors are associated with breed standards, an owner of an overweight/obese breed that meets these standards may perceive their cat as ideal for their breed and not overweight/obese.

2.3.4 Environment and Activity level

Various environmental factors have been associated with feline obesity, including indoor versus outdoor housing, presence of feline or canine housemates, and activity level (Allan

et al., 2000; I. Robertson, 1999; Russell et al., 2000; Sloth, 1992). In a population-based study where 458 households were randomly surveyed, 21.5% of cats housed predominately indoors were overweight compared to 17.5% of predominately outdoor cats (I. Robertson, 1999). Fifty percent of indoor cats were overweight or obese compared to 30% of outdoor cats in a study involving 233 cats referred to a small animal practice (Sloth, 1992). Utilizing data from a large-scale longitudinal study ('Bristol Cats'), cats with limited or no outdoor access at 12.5-13 months of age doubled the risk for overweight and obesity (Rowe, Browne, Casey, Gruffydd-Jones, & Murray, 2015). The association between indoor housing and obesity is not consistent across studies (Colliard et al., 2009; Courcier et al., 2012; Öhlund et al., 2018; Russell et al., 2000). Other variables that influence the risk of obesity in the indoor cat include pet housemates. Having other pets in the household appear to influence the risk of obesity in indoor cats. Cats living in households with dogs were less likely to be obese (Allan et al., 2000). In addition, cats living in households with one or two cats had a greater risk of obesity compared to cats living in households with greater than two cats (I. Robertson, 1999). It is possible these environmental factors affect cat activity level and owner behavior. Limited outdoor access provides less opportunity for roaming, hunting, and interaction with animals outside the home which may decrease energy expenditure (Slingerland, Fazilova, Plantinga, Kooistra, & Beynen, 2009). Cats residing in a single or two cat household may spend less time and energy playing and fighting compared multi-cat households (I. Robertson, 1999). In addition, more attention and food may be offered to cats living in one or two cat homes (I. Robertson, 1999).

2.4 Diagnosing Obesity

2.4.1 Body weight

Body weight is the most simplistic and possibly the most widely-used method to measure body mass. Successive body weight measurements at regular exams is an objective measure that can identify trends in body composition overtime. Body weight can provide a crude assessment of body composition when considering breed standards for pure breed cats; however, individual variation within breeds must be considered. Body weight alone, however, provides no measure of fat to fat free mass ratio (Bjornvad et al., 2011; Shoveller et al., 2014). Although fat composition can affect body weight, muscle mass, fluid accumulation, organomegaly, or large tumor formation can influence weight as well; thus, body weight measurement has a low specificity when used in the absence of other measurements to assess body composition.

2.4.2 Body Composition

Body condition scoring is a practical, although subjective, way to determine body composition. Body condition scoring utilizes visual and tactile assessments (Appendix A) to classify animals as underweight, ideal, overweight, or obese in production and companion animals (Burkholder, 2000). Various BCS systems have been described in companion animals, including a nine-point scale and five-point scale (Bjornvad et al., 2011; D Laflamme, 1997a; Shoveller et al., 2014). The nine-point scale ranges from 1-9 with a score of 1 indicating severe emaciation while a score of nine is indicative of severe obesity. A score of five is considered ideal for healthy cats. The five-point scale ranges from one to five with a score of one being emaciated, a score of five indicating severe

obesity, and a score of three indicating ideal body condition and therefore ideal body weight (D Laflamme, 1997a, 1997b). The nine-point scale is the most widely accepted in both dogs and cats and has been proven to correlate with fat mass (Bjornvad et al., 2011; Holden et al., 2006; D Laflamme, 1997a, 1997b; Mawby et al., 2004). Furthermore, the nine-point scale has repeatedly shown inter and intra-evaluator repeatability, reproducibility, and predictability in cats and dogs (D Laflamme, 1997a, 1997b). Body condition score is used to estimate ideal body weight for overweight and underweight cats. Each point on the nine-point scale represents approximately a 10% increase or decrease from ideal body weight. For example, a cat with a BCS of 8/9 is 30% over or 130% of ideal body weight.

Dual energy x-ray absorptiometry (DXA) utilizes differential absorption of two different energy levels to determine body mass composition (Borga et al., 2018). This modality is commonly used in research settings as a reference standard when validating other methods but is impractical for routine clinical use due to availability, cost, and need for anesthesia (Bjornvad et al., 2011; Hawthorne A, 2000; Holden et al., 2006; D Laflamme, 1997a, 1997b; Shoveller et al., 2014; Witzel et al., 2014a, 2014b).

Muscle Condition Score (MCS) complements the BCS assessment as obese cats may have reduced muscle mass. Muscle condition scoring, like BCS, is a subjective visual and tactile assessment of muscle mass at the skull, scapulae spine, and the wings of the ilia (see Appendix B). Cats can be graded a normal, mild muscle loss, moderate muscle loss, and severe muscle loss. It is possible for cats to have increased adiposity along with muscle loss, thus evaluating muscle condition along with body condition should be a part of a routine exam.

2.5 A Need to Improve Obesity Management

2.5.1 Weight Management Plan

We need to intervene at multiple points of the circle of nutrition (assess the patient, food/feed and feeding management). There is a need to raise society's awareness of feline obesity and there is a need to make prescribed weight loss easier for owners. Making prescribed weight loss plan easier to implement involves consideration for activity and satiety.

Prescribed weight loss is of utmost importance to decrease the risk of developing various comorbidities associated with excessive adiposity. There are two main stages of weight management, weight loss and healthy weight maintenance (German, 2016).

Nutritional evaluation for weight loss should be performed using a systematic and comprehensive method. Physical evaluation includes assessing the patient's body weight, BCS, MCS and other factors that may play a role in obesity such as life stage, reproductive status, and overall health; however, body weight, BCS, and MCS are most important for providing baseline measurements and monitoring progress. Once the cat is determined to be above ideal, owners must be made aware their cat is overweight or obese for the weight loss stage to be successful. Clients may not recognize their cat is overweight because owners tend to underestimate their cat's BCS (Allan et al., 2000; Colliard et al., 2009; Courcier et al., 2010). If an owner does not perceive their cat to be overweight, they may be reluctant to comply with a prescribed weight loss plan. Therefore, client communication is key in helping owners not only recognize their cat's condition but also understand the implications of excess adiposity if a weight loss plan is to be successful.

The target or ideal body weight should be established to determine the cat's caloric intake to promote weight loss. This can be performed by searching the medical record for a historical body weight that correlates with an ideal BCS (preferred method) or calculating the ideal body weight using the current BCS if an ideal BCS and body weight are not available (Brooks et al., 2014). Each BCS above a five on a nine-point scale is equivalent to about 10% above ideal body weight (D Laflamme, 1997a). Therefore, a cat with a BCS of 8/9 is about 30% above its ideal weight. Obese cats greater than 40% above their ideal body weight, or greater than a 9/9 BCS may prove more difficult in determining their ideal body weight during their initial assessment.

Not only does the ideal body weight need to be determined to establish an appropriate weight loss plan but also information regarding the diet. A thorough diet history including the brand and name of the current diet, quantity fed, brand and name of treats, the number of treats fed, supplements offered, information regarding the feeding management and environmental factors should be obtained. Various diet history forms have been developed to collect this information ("ACVN Diet History Form";"WSAVA Short Diet History Form"). Feeding management and environmental factors include who is the primary feeder, how the pet is fed, where the pet is fed, when the pet is fed, enrichment, outdoor access etc. are just as important as what is fed and how much is fed (Baldwin et al., 2010).

Owner evaluation allows for better understanding of how food plays a role in the client and pet relationship. Additional food/calories may be offered for training purposes or bonding and may be an important aspect of the relationship the client has with their cat (Brooks et al., 2014; Eirmann, 2016). Identifying these aspects will aid in tailoring a

weight loss plan appropriate for the client and patient's lifestyle. Furthermore, client assessment can provide insight into the client's willingness to change and comply with a weight loss plan. Successful weight loss correlates with owner behavior. Churchill and Ward (2016) utilizes the transtheoretical model, or stages of change model, to understand a client's willingness to alter their behavior (table 2.2). The transtheoretical model focuses on the process of behavior change, especially as it relates to a person's willingness to adopt and maintain healthy behaviors. This model was originally studied and evolved smoking cessation research Prochaska and DiClemente (1983); however, this model can be used for other health behaviors as well. The transtheoretical model posits individuals move through six stages of change when modifying their behavior (Glanz, Rimer, & Viswanath, 2015). These stages are described below as they relate to obesity management and can help determine the veterinarian's course of action.

Client Stage of Change	Stage of Change Characteristic	Client Characteristics	Veterinary Intervention
Precontemplation	Does not intend to take action within the next 6 months.	May not be willing to change because may not identify their cat as overweight/obese.	Offer general information and express concern. Implement monitoring plan to evaluate patient for comorbidities associated with obesity.
Contemplation	Aware of the issue and plans to take action within the next 6 months.	Client is aware of the pros and cons but may be caught in a state of chronic contemplation.	Discuss client's feelings regarding a weight loss plan. Educate the client about obesity and the benefits of weight loss.
Preparation	Plan to take action within 1 month.	Aware their cat is overweight/obese and taking steps toward behavior change.	Discuss course of action.
Action	Positive change in health behavior has occurred for less than 6 months.	Changes in health behavior have been made such as offering a weight loss diet and decreasing caloric intake.	Offer support and feedback. Design a tailored weight loss plan. Consistent monitoring of weight loss and BCS.

Maintenance	Positive change in health behavior has occurred for greater than 6motnhs.	Maintenance of the weight loss plan.	Continued support, feedback, monthly weight and BCS evaluation. Adjust the weight loss plan as necessary.
Termination	No desire to return to previous risky health behavior.	Successfully implements the weight loss plan and maintains healthy behavior change post weight loss.	Monitor weight, BCS, and assess nutrition at future wellness exams.

Table 2.2 Transtheoretical Model: Client Stages of Change
Adapted from Glanz et al. (2015) and Churchill (2010)

The goal of a weight loss program should be to reduce calories while maintaining lean muscle mass. Feeding an appropriate diet and number of calories is key. Clients should be instructed to feed based on a specific calorie target tailored to their pet's needs and not based on the diet's recommendations placed on the label. Diet feeding instructions may overestimate calorie needs. After determining the ideal body weight using the methods described above, the daily caloric intake to promote weight loss should be determined. Caloric intake should be calculated based on the pet's RER ($70*kg^{0.75}$) at their ideal body weight (Brooks et al., 2014). Feeding 80% of the cat's RER may be appropriate for weight loss. If the cat is already consuming 80% of its RER then further restriction is needed. Other methods that has been described for energy restriction include feeding 60-70% of the caloric requirement needed to maintain ideal weight (60-70%*40-50kcal/kg/day) and feeding 80% of the current caloric intake (Brooks et al., 2014; Michel & Scherk, 2012). Clients should be made aware this is a starting point and individual variation may require calorie adjustment.

Caloric restriction should be achieved while feeding a complete and balanced diet (Dottie P. Laflamme, 2006). Per AAFCO guidelines, diets labeled as light, lite, or low-calorie must contain less than or equal to 3250 kcal ME/kg for diets containing less than 20%

moisture, less than or equal to 2650 kcal ME/kg for diets containing 20-65% moisture and 950kcal ME/kg for diets containing greater than 65% moisture (*Association of American Feed Control Offical Publication* 2017). Many OTC dry and canned diets exceed this range (D. E. Linder & Parker, 2016); see table 2.3. Furthermore, it is important to provide pets a diet that is formulated for weight loss and not simply decrease an OTC maintenance diet because essential nutrient deficiencies may occur. When a maintenance diet is restricted to meet caloric needs, all essential nutrients are restricted as well. Veterinary therapeutic weight loss diets are formulated with a higher essential nutrient to energy ratio; therefore, essential nutrient recommendations can be met in the face of decreased energy intake (Hoelmkjaer & Bjornvad, 2014).

Weight loss diets are generally formulated to not only be low calorie but also low fat, high protein, and increased fiber; see table 2.3. With an energy density of nine kcals/g, dietary fat is about twice as energy dense as protein (four kcal/g) and carbohydrates (four kcal/g) and therefore has a major effect on energy density of the diet (Stelmach-Mardas et al., 2016). Generally, by decreasing the fat content, the energy density of the diet will decrease as well. Consuming a low-energy dense diet allows for a higher volume of food to be fed with less caloric intake. Consumption of increased food volume may promote satiety and decrease food seeking behavior in some pets.

Fat loss should not be the only concern during the weight loss process. Consuming adequate protein is vital in maintaining lean mass (Hoenig et al., 2007; D. P. Laflamme & Hannah, 2005). Increasing protein concentration not only maintains lean muscle mass but has been shown to increase weight loss in cats and dogs (Bierer & Bui, 2004; Hannah & Laflamme, 1998).

The addition of fiber to the diet aids in reducing the caloric density while promoting satiety, thus limiting calorie consumption. Dogs and cats have both shown to reduce food intake when fed a high fiber diet (Fekete, Hullar, Andrasofszky, Rigo, & Berkenyi, 2001).

Type of Diet	Protein (g/Mkcal)	Fat (g/Mkcal)	Crude Fiber (g/Mkcal)	Energy Density (kcal ME/kg, as fed)
VTWD (canned)	140.4	32	15.3	547
VTWD (canned)	123	30	50	733
VTWD (canned)	121	37.6	32.2	804
VTWD (canned)	117.2	32.8	6.3	581
VTWD (canned)	105	37	27	788
VTWD (dry)	159	23.7	16.8	3240
VTWD (dry	109.8	26.2	8.6	3,388
VTWD (dry)	108.4	28.7	44.6	2,942
VTWD (dry	108	37	27	3,393
VTWD (dry)	107	26	43	3,018
OTC (canned)	143.7	45.4	1.1	945
OTC (canned)	132.8	31.9	9.6	805
OTC (canned)	122.4	37.2	7.84	880
OTC (canned)	107	48	6	968
OTC (canned)	94	45	6	1,040
OTC (dry)	86.2	35.6	2.8	4060
OTC (dry)	84.4	39.6	11.6	3,596
OTC (dry)	82	51	3	4,011
OTC (dry)	80.9	41.7	12.5	3,656
OTC (dry)	73	52	2	4,100

Table 2.3 Nutrient Content of VTWD and OTC Adult Maintenance Diets

Feeding management should be discussed with owners to ensure pets receive an appropriate diet and calorie restriction. Many owners feed treats, including commercial treats and human food, but may not realize treats add to their pet's daily caloric intake. One survey showed 21% of cat owners feed at least one treat per daily (Dorothy Laflamme et al., 2008). Not only do treats add to daily calories, they are typically not complete and balanced and should be limited to no more than 10% of the pet's daily caloric intake to ensure a balanced diet is being fed (Brooks et al., 2014; German, 2016).

The diet should also be measured to ensure caloric needs are met. Common measuring devices are measuring cups and kitchen scales. Measuring cups have been shown to have poor precision between and within individuals when used to measure kibble and variable accuracy ranging from 18% underestimation to 80% overestimation (German, Holden, Mason, et al., 2011). Clients may need to be instructed on proper measuring technique e.g. ensuring the diet is level with the rim of the measuring cup. Although utilizing measuring cups seems to be more popular in the United States, kitchen scales are likely a better option to ensure the pet is fed the appropriate number of calories. Multi-pet households may be a challenge during the weight loss plan. Housemates may provide a source of food outside of the recommended diet. Various methods such as supervised feeding, feeding in separate rooms, utilizing microchip or similar feeders, and raised feeding areas where overweight cats cannot access can be utilized to discourage access to another pet's food source.

Human studies have indicated that not only calorie restriction, but physical activity promotes weight loss as well (Andreou, Philippou, & Papandreou, 2011; Ross et al., 2000). Increasing physical activity in a healthy dog can be achieved easily by walking, running, playing catch, and/or going to a dog park. Beginning a physical activity regimen in cats may prove more challenging. Environmental enrichment may help to increase physical activity by providing an outlet for play. Play behavior is linked to a cats natural predatory sequence: stalk, chase, pounce, bite (Herron & Buffington, 2010). The addition of food toys can aid in environmental enrichment to allow cats to express their predatory nature such as hunting and stalking (Dantas, Delgado, Johnson, & Buffington, 2016). Furthermore, empirical data has indicated food toys aid in slowing food consumption

(Dantas et al., 2016). Slowing food consumption may improve begging behavior. Other forms of environmental include hanging toys, tossing food for the cat to chase, dragging a toy for the cat to chase, self-propelling toys, cat-nip filled toys, and wand toys (Herron & Buffington, 2010; "Increasing the Activity,")

Monitoring the weight loss plan is just as important as designing and implementation of the plan. Regular follow up appointments throughout the process may decrease irritation and increase inspiration and maintain compliance to the weight loss plan (Yaissle, Holloway, & Buffington, 2004). A weight loss rate of 0.5-2% of the current body weight is appropriate for cats (Brooks et al., 2014; D. Linder & Mueller, 2014). Knowing the target weight and weight loss rate allows for calculation of the approximate length of time it will take for the patient to reach their target body weight and BCS. Clients should be informed of the length of time it may take for their pet to achieve their ideal weight. Furthermore, during this process it is common for animals to plateau and further restriction may be needed to promote further weight loss (D. E. Linder & Parker, 2016). If the pet plateaus, or gains weight, owner compliance and feeding managing should be evaluated and altered if necessary. If the owner is compliant and feeding management is adequate then the caloric intake should be reduced by 10-20% (Brooks et al., 2014). Monitoring owner compliance, BCS, MCS, and body weight should be performed every two weeks until the patient is losing weight at an appropriate rate (0.5-2%). Once the patient is losing appropriately, monthly follow-ups should be implemented.

Caloric intake will need to be titrated for weight maintenance once the patient has reached their target body weight. The caloric intake can initially be increased by 5-10% to discontinue weight loss and promote weight maintenance; however, some patients may

not need an increase in calories if they plateaued at their ideal weight (Brooks et al., 2014; D. E. Linder & Parker, 2016). Maintenance energy requirements for dogs that were previously overweight appear to be low. The mean caloric requirement for maintenance of ideal body weight in a group of dogs post weight loss was only 10% above the caloric intake needed for weight loss (German, Holden, Mather, Morris, & Biourge, 2011). Another study indicated obesity can be more easily induced in dogs that were previously overweight (Nagaoka, Mitsuhashi, Angell, Bigley, & Bauer, 2010). Nagaoka et al. (2010) induced obesity in nine female beagles followed by implementing a weight loss plan and then re-induced obesity. Less time and fewer calories (1875-2250kcal/day versus 1125-1250kcal/day) were needed to re-induce the same level of obesity (Nagaoka et al., 2010). This may be reflected in cats as well. A proper post weight loss diet should be implemented that meets the pet's metabolic needs. Due to the low energy requirements, continuing to offer a veterinary therapeutic weight loss diet is appropriate. Other options include feeding an OTC weight management diet. Some clients may prefer to feed the pet's original diet prior to starting the weight loss plan or other OTC adult diets that may or may not be appropriate depending on the degree to which calories are decreased. Body weight and BCS evaluation can occur yearly once the number of calories needed for weight maintenance have been established and the patient is weight stable. Although follow-ups are less often, consistent monitoring post weight loss is vital because regaining lost body weight can occur. One study investigated whether client owned cats regained weight post weight loss and found in a group of 26 cats, 46% of cats gained weight with 58% of those cats regaining more than half of the weight that was lost (Deagle, Holden, Biourge, Morris, & German, 2014). Clients should also be instructed on

how to monitor BCS using a validated scale such as those described by D Laflamme (1997a) and/or Holden et al. (2006) to ensure pets are maintaining their ideal weight and BCS between appointments.

2.6 Quality of Life Assessment

Quality of life (QOL) has been described as the balance between pleasant and unpleasant feelings and is related to happiness, contentment, satisfaction and psychological well-being in humans and animals (McMillan, 2003). Wojciechowska and Hewson (2005) suggest an animal's feelings, physical state, and ability to satisfy its nature must be considered when evaluating an animals QOL. This can be difficult to evaluate because QOL is a very personalized state of being. Thus, owners may have differing perceptions of quality of life indicators for their cats. An essential goal of veterinary medicine is to maintain/improve the QOL of pets. A pet's QOL can be important TO owners and comorbidities associated with overweight and obesity can negatively affect a pet's quality of life (German et al., 2012). Quality of life assessments are valuable in making clinical decisions to ensure a cat's overall wellbeing is addressed. There are multiple situations where QOL assessments are useful, including, routine health screening to identify possible concerns, monitoring health over time and comparison between research groups (Yeates & Main, 2009). Furthermore, QOL assessments may be able to improve treatment. If clients perceive their pet is improving via QOL assessment, compliance may be increased, or if a pet is not improving, veterinarians can alter treatment to increase likelihood of success. Multiple studies have researched QOL assessments for dogs and cats and range from broad open-ended qualitative assessments to structured quantitative

measures such as visual analogue scales (Chang, Mellor, & Anderson, 2006; Mullan & Main, 2007). Quality of life assessments may be general or specific to certain diseases. In cats, QOL has been assessed in the context of cardiac disease, joint disease, cancer, diabetes, chronic pain (Benito, Gruen, Thomson, Simpson, & Lascelles, 2012; Budke et al., 2008; Freeman et al., 2012; Iliopoulou, Kitchell, & Yuzbasiyan-Gurkan, 2013; B. D. Lascelles et al., 2007; Lynch, Savary-Bataille, Leeuw, & Argyle, 2011; Niessen et al., 2010; Yazbek & Fantoni, 2005). Benito et al. (2012) evaluated owner-perceived indices of QOL in cats with degenerative joint disease. In this study, 830 QOL indices were placed into six behavioral domains including active transition (moving from a point A to point B), eating and drinking, grooming and scratching, playing and hunting, resting and observing, and social activities. Interestingly, only forty percent of the QOL indices were classified as 'active items' or involving motion while 60% were classified as 'inactive items', not involving motion. Therefore, it appears as though cat owners expect little activity from their cats. In addition, research is lacking regarding validated questionnaires assessing physical activity in cats. Benito et al. (2012) created an assessment evaluating QOL indicators which included active movement, but it was not specifically designed to measure physical activity.

2.7 Prevention

Body weight and BCS are quick and useful tools to evaluate health and should be assessed, discussed, and recorded in the patient record routinely along with information regarding the patient's diet ("Development of new canine and feline preventive healthcare guidelines designed to improve pet health," 2011; "WSAVA Nutritional

Assessment Guidelines," 2011). Unfortunately, this is not always a reality. Lund et al. (2005) reported a discrepancy between the prevalence of obesity (6.4%) and reported diagnosis of obesity (2.2%) and the prevalence of overweight cats (28.7%) compared to the reported diagnosis (1.4%). In another study, a subset of 29,401 medical records for domestic short-hair cats were obtained to study obesity prevalence; only 50% of records had both BCS and body weight recorded, 32.8% had only the body weight recorded, 2.1% recorded only the BCS, and 15.1% had recorded neither the BCS nor the body weight (Gates et al., 2019). This may suggest veterinarians do not recognize overweight/obesity as a disease or a disease state in need of the same consideration as other diseases.

A kitten's initial visit should highlight feeding a diet formulated for feline growth and the quantity to feed to maintain an ideal BCS (D. Linder & Mueller, 2014). Kittens can be spayed/neutered as early as 8 weeks of age (Howe et al., 2000). Gonadectomy is a risk factor for obesity and has been shown to alter food intake and possibly caloric needs (Alexander et al., 2011; Fettman et al., 1997; Hoenig et al., 2007). Therefore, continued nutritional assessment and BCS monitoring post gonadectomy is prudent. If the BCS increases above ideal, feeding management must be altered e.g. offering a less energy dense growth formula and/or eliminating or decreasing treats/snacks.

Middle-age cats have a higher risk for overweight and obesity (Lund et al., 2005). Consistent monitoring of body condition and nutritional assessment should continue into adult to aid in early detection of and correction of overweight cats.

The primary goal of weight management is prevention. Patient assessment and client communication beginning at the first veterinary visit and continuing in a consistent

manner throughout the life of the patient is vital in obesity prevention which may decrease the risk of morbidity and mortality in the domestic cat population.

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CHAPTER 3: EFFECT OF FOOD TOYS ON OWNER-PERCEIVED CAT QUALITY OF LIFE DURING A PRESCRIBED WEIGHT LOSS PLAN

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3.1 Abstract

Obesity is the most common nutritionally sensitive condition among cats. Several factors contribute to obesity; however, the primary factor is an imbalance between energy intake and energy expenditure. Obesity, in multiple species, has been associated with dermatoses, insulin resistance, hepatic lipidosis, and more. Weight loss plans aid in managing obese cats to preserve quality of life and reduce medical expenses. However, owners may discontinue weight loss plans if they perceive their cat to have a poor quality of life. The purpose of this study is two-fold. The primary objective is to determine the effect of a food toy on owner-perceived quality of life of obese cats during a weight loss plan. The secondary objective is to determine the effect of a food toy on cat activity. We hypothesize that cats fed via a food toy will have a higher owner-perceived quality of life and be more active than obese cats fed with a food bowl. Fifty-five adult cats 1-10 years of age, altered, with a BCS of 7/9 or greater, no signs of clinical disease, and housed exclusively indoors were enrolled into this randomized double-blinded study. Enrolled cats were randomized into one of two groups: food toy (n=26) or food bowl (n=29. Owners completed an initial questionnaire and receive a prescribed weight loss plan, bag of dry veterinary therapeutic cat food formulated for weight loss, measuring cup, and

food bowl or toy. Body weight and body condition score were checked monthly. Owners completed a monthly questionnaire to assess their cat's quality of life. Of the 44 cats in the final analysis, 66% (n=29) either lost ≥ 2 BCS points or achieved ideal BCS. Low-calorie vegetables were offered to cats whose owners reported food seeking behavior (n=32). A statistically significant increase in owner perceive-quality of life was reported when comparing the initial weight loss appointment to the final follow-up visit; however, no statistical difference in owner-perceived quality of life was noted when comparing pets fed via a food toy versus a food bowl; therefore, further studies regarding feeding management for cats during a weight loss plan should be explored.

3.2 Introduction

The prevalence of overweight and obesity in US cats is as high as 60% (*Association for Pet Obesity Prevention*, 2018). Feline obesity is associated with comorbidities such as insulin resistance, hepatic lipidosis and urinary tract disease (Appleton et al., 2001; Center, 2005; Hoenig et al., 2007). These conditions can be a financial and emotional burden for pet owners. Banfield reported 36% more money is spent on diagnostic procedures for overweight cats and an estimated additional $1,178 is spent per year on feline obesity-related issues (*Banfield Pet Hospital State of Pet Health Report*, 2018). Weight loss plans should be instituted for obese cats to preserve quality of life.

Obesity management is multi-factorial and includes patient assessment (e.g. body condition score), assessment of the current diet, effective client education, owner motivation, a detailed weight loss plan and monitoring (Brooks et al., 2014; Churchill, 2010; Churchill & Ward, 2016; German, 2006). Improving owner perception of weight

loss may enhance compliance and success of obesity management plans and help to reduce the prevalence of feline obesity. Owner perceptions of quality of life (QOL) during obesity management has been assessed in the dog and was improved after weight loss (German et al., 2012).Owner's perception of their cat's quality of life (QOL) has been assessed in the context of cancer, osteoarthritis and cardiac disease management, but not in the context of obesity management (Benito et al., 2012; German et al., 2012; Thornton, Cave, Bridges, & Stell, 2018). Activity can positively influence the success of weight loss, but, promoting physical activity in cats can be a challenge. Conversely, weight loss may positively influence activity. Capturing activity objectively, through use of an activity monitor, can complement subjective owner-perceptions of activity (de Godoy, Ochi, de Oliveira Mateus, de Justino, & Swanson, 2015; Lascelles et al., 2008; Naik et al., 2018).

A detailed diet plan should include a specified diet (food, treats, other) and instructions on how much and how often to feed. A weight loss diet should facilitate calorie restriction while maintaining adequate amounts of essential nutrients and satiety. In addition, careful selection of the diet can help to decrease negative behaviors associated with calorie restriction (e.g. disruptive food seeking behavior). Veterinary therapeutic weight loss diets are low in fat and are typically fiber-enhanced with lower energy density, which allows a higher volume of food to be fed (D. E. Linder & Parker, 2016). Furthermore, veterinary therapeutic diets are more highly fortified in essential nutrients per calorie to prevent malnutrition during energy restriction. How the diet is fed (e.g. specified volume divided over multiple meals per day) can also help to curb disruptive

food seeking behavior. Disruptive food seeking behavior can negatively influence owner-perceived quality of life and potentially the owner's own quality of life.

Food dispensing toys have been recommended as an environmental enrichment tool and allow for cats to express their natural predatory nature (Herron & Buffington, 2010). Food dispensing toys may slow food consumption, prolong the feeding time, increase activity and decrease the time between meals. Therefore, food toys may help curb disruptive food seeking behavior in cats and improve owner-perceived quality of life. The impact of food toys on weight loss success in cats has not been investigated.

The aim of this study is to determine the effect of a food toy on owner-perceived quality of life of obese cats during a weight loss plan. We hypothesize that obese cats fed via a food toy will have a higher QOL.

3.3 Material and Methods

3.3.1 Study Participants and Experimental Design

Study participants were recruited from April 2017 – August 2018 for this randomized, double-blind clinical trial by way of oral announcements by the Virginia Maryland College of Veterinary Medicine (VMCVM) clinical trials coordinator at local continuing education events, radio advertisement, and school website. Cats were included in the study if they were 1-10 years of age, neutered, housed exclusively indoors, had a BCS greater or equal to 7/9, consuming a majority commercial dry kibble diet, and able to be fed separately. Cats were excluded if there was evidence of disease (e.g. chronic renal disease, cardiac disease), cats were taking medication other than preventatives, owner was unwilling to return for monthly rechecks and/or owner was unwilling to complete an

initial and monthly QOL questionnaire. Cats were excluded if they were unwilling to consume the commercial veterinary therapeutic weight loss study kibble.

Enrolled cats were weighed, body condition scored and assigned a random study number by use of Microsoft Excel random number generator. Study numbers coincided with 'study kits' that were prepared by a non-blinded undergraduate research assistant. The kits contained a client consent form, initial questionnaire, monthly questionnaire, commercial dry feline veterinary therapeutic weight loss diet (single diet for all participants), feeding instructions, measuring cup and food toy or bowl. The initial metabolizable energy (ME) goal for weight loss was calculated as 80% resting energy requirements ($70*BW^{0.75}$) for ideal body weight (Brooks et al., 2014). Fifty-five cats were randomized into one of two groups, food toy (n=26) or food bowl (n=29) group. The initial and monthly questionnaires were adapted from Benito et al. (2012). For the initial questionnaire, owners ranked the importance of six factors in assessing their cat's quality of life from one being the most important to six being the least important: eating and drinking, engaging in social activities with humans and pets, resting and observing, grooming and scratching, playing and hunting, and moving from one point to another (Benito et al., 2012). For the monthly questionnaire, completed at the first and subsequent recheck visits, owners ranked their cat's ability to perform each of the six factors on a scale from zero (impossible) to six (normal). The overall QOL was calculated as previously described by Benito et al. (2012). The ranking provided for owner-perceived importance for each category was multiplied by the ability score at each visit. The overall QOL score was the sum of the scores obtained.

Owners were instructed to transition their cat to the study diet over a four to eight-day period. Cats in the bowl group were instructed to use a two-bowl technique; one bowl with the cat's current food, the other with the study diet. The proportion of the current food offered was to gradually decrease in one bowl and the proportion of the recommended diet gradually increased in the other. Cats in the toy group were instructed to transition the cat to the study diet first and then introduce the food toy. The un-blinded investigator, (M.S.) reviewed the diet plan and answered diet questions throughout the study.

Owners returned with their cats for monthly rechecks of body weight, body condition score and diet compliance. Monthly rechecks were conducted by two investigators (L.D. and M.S.). One author, L.D. was blinded to cat treatment (toy vs. bowl). The ME goal for weight loss was adjusted monthly as needed to achieve a weight loss rate of 0.5-2% weight loss per week (Brooks et al., 2014). If any cat's weight loss did not achieve 0.5% loss per week, the current diet was re-assessed, and the weight loss diet was reduced to offer 80-90% of prior ME recommendation. Similarly, if any cat's weight loss rate exceeded 2% body weight per week the current diet was re-assessed, and the weight loss diet was increased to offer 110-120% of prior ME recommendation.

The study for each cat was considered complete once the cat lost at least two BCS points and/or reached an ideal BCS of 5/9. Owners were debriefed at the end of the study to disclose the purpose of the study. Owners of cats in the food bowl group were provided with a food toy upon completion of the study.

3.3.2 Pilot Study

A pilot study (Shepherd, unpublished data) was performed to test the monthly questionnaire adapted from Benito et al. (2012) and to test the practicality of the food toy. Twelve VMCVM student-owned adult cats of various breeds were enrolled in a student-run weight loss challenge in the fall of 2015. Upon initiation of the weight loss challenge, cat owners were asked to rank the importance of six activities (eat & drink, engage/social, groom & scratch, move, play & hunt, and rest & observe) in the evaluation of cat quality of life (Initial Questionnaire) (Benito et al., 2012). Cats were assigned a weight loss plan that included feeding a veterinary therapeutic weight loss diet at a rate of 80% RER ($0.8(70*BW^{0.75})$) for ideal body weight. Student cat owners were asked to feed the feline weight loss kibble. At monthly rechecks, cat owners rated their cat's ability to perform the 6 activities (Monthly Questionnaire). Cats began the challenge with a mean +/- (standard deviation [SD]) body weight and BCS of 6.3kg +/- (1kg) and BCS 8/9 +/- (1/9). Over a 13-week period (9/12/2015-12/13/2015), cats lost a total mean (SD) of 7% (5%) of initial body weight body weight at a mean (SD) rate of 0.55% (0.39%) initial body weight per week. Ability scores improved in five of the six activities over the 13-week period (9/12/16-12/1316). A quality of life score was calculated as the sum of the products of activity rank and ability score. The mean (SD) quality of life score at the end of the study was 117 (6.1). The majority (7/10) students reported the food toy to be a positive experience. Three of 10 owners reported food toy difficulty due to other household pets (i.e. other pets like the toy).

3.4 Statistical Analysis

The number of cats per group was determined using the two-sample t-test procedure of PASS to detect a five-point difference in the mean quality of life score for cats in the

food toy vs. bowl group with a power of 81%. The power analysis was conducted with the assumption that quality of life scores would be five-points lower (112) than that reported in the preliminary study (117; all cats were fed by food toy). Standard deviation for both means was assumed to be 6.1. PASS showed that 25 cats per group would be needed for the study.

Outcomes included owner perceived quality of life (QOL), activity of cats, BCS, percent body weight loss, and percent body weight loss per week. Normal probability plots showed that QOL scores and BCS were skewed while activity of cats, percent body weight loss, and percent body weight loss per week followed a normal distribution. Accordingly, skewed data were summarized as medians (range) and normally distributed data were summarized as means ± standard deviation. Effects of treatment groups and visit (time during the study), and the interaction between group and visit on QOL (primary outcome) were assessed using linear generalized estimating equations (GEE). The interaction between group and visit was further analyzed to compare visits within each group, and to compare groups within each visit followed by Tukey's procedure for multiple comparisons. Repeated measures over cats where modelled using the compound symmetry correlation matrix. Effects of treatment groups and visit (time during the study) on, activity and percent body weight loss per week were assessed (separately for each outcome), using mixed-model repeated-measures ANOVA. Each of the linear models specified treatment group, visit, and interaction between group and visit as fixed effects with Kenward-Roger approximation as the denominator degrees of freedom. G-side variation in the data was modeled by specifying cat identification within group as a random effect while the R-side variation in the data was modeled by specifying a first

order autoregressive covariance matrix. The interaction between group and visit was further analyzed to compare groups at each visit and to compare visits within each group followed by Tukey's procedure for multiple comparisons. QOL for all cats upon entering the study were compared to their last visit using Friedman's chi-square test. QOL scores were also compared between cats that completed the study and cats that did not complete the study; and between cats that achieved a body condition score of 5/9 versus body condition score two using GEE. Statistical significance was set to $p < 0.05$. All analyses were performed using SAS version 9.4 (Cary, NC, USA).

3.5 Results

3.5.1 Cats

Fifty-five adult client-owned cats were enrolled. Of the 55 enrolled, eleven enrollees were pulled from the study for various reasons including failure to consume the study diet (n=1), constipation (n=1), cat stress or behavioral issues (n=1), inability for the owner to return monthly (n=3), hairballs (n=1), lost to follow-up (n=1), hunger (n=1), lack of improvement (n=1) and client suspected adverse food reaction (n=1). Forty-four cats were included in the final analysis. There was no statistical difference between the food toy and food bowl groups at baseline (age [p=0.5], body weight [p=0.8], or BCS [p=0.4]).

Group	**Female count**	**Female Spayed count**	**Male Neutered count**	**Age mean +/- SD in years**	**Weight mean +/- SD in kgs**	**BCS median (range)**
Food Bowl	0	13	8	5.6 +/- 2.5	7.9 +/-1.3	8 (7-9)
Food Toy	1	8	14	5.1 +/-2.9	7.7 +/-1.9	8 (7-9)

Table 3.1 Characteristics of Study Group Participants at baseline

3.5.2 Weight loss and BCS

On average, cats completed the study criteria by achieving ideal body weight (n=13) in 9 months (SD, 3) or lost two body condition scores (n=17) in 11 months (SD, 2). Changes in percent body weight per week for the food bowl groups ranged from a 7.7% increase in body weight to a 2.5% loss in body weight with a mean of 0.6% (SD, 0.6) weight loss. Changes in percent body weight throughout the study ranged from a 5.4% increase in body weight to a 3.0% decrease in body weight per week with a mean of 0.6% (SD, 0.5) weight loss per week for cats provided a food toy. No statistical difference was noted for percent body weight loss per week between the food toy and the food bowl group (p=0.9). Cats in both the food bowl and food toy group lost a median of 2 BCS with a range of 5-8 BCS and 5-9 BCS for the food bowl and food toy groups respectively.

Group	**Weight loss per week mean +/- SD (%)**	**BCS median (range)**
Food Bowl	0.6 +/- 0.2	6 (5-8)
Food Toy	0.7 +/- 0.3	6 (5-9)

Table 3.2

3.5.3 Owner-Perceived QOL

Owners ranked 'Eating & Drinking' as the most important and 'Moving from One Point to Another' as the least important quality of life factor for the initial survey.

	Ranking
Eating & Drinking	1 (1-5)
Engaging in Social Activities with Humans & Pets	3 (1-6)
Resting & Observing	4 (1-6)
Grooming & Scratching	4 (1-6)
Playing & Hunting	4 (1-6)
Moving from One Point to Another	5 (1-6)

Table 3.3 QOL Factors Ranked by Clients
[a]Data expressed as median (range)

Due to rolling admission and variation in number of months each cat was enrolled with few (n=4 food toy; n=19 bowl) continued past 9 visits, data was processed for the first 9

visits of each cat's weight loss. Regarding the primary objective, there was no significant difference in QOL between cats fed via a food bowl versus cats fed via a food toy. However, owner-perceived QOL was higher ($p<0.0001$) at the last recheck as compared to the initial evaluation (table 3.4). Owner-perceived QOL increased significantly for 'engage/ socialize' ($p=0.007$), 'groom and scratch' ($p=0.0002$), 'move from one point to another' ($p=0.0001$), and 'play and hunt' ($p=0.000$). Of the cats that completed the study, owner-perceived QOL was not influenced ($p=0.27$) by group (e.g food toy vs. bowl). Furthermore, owner-perceived QOL did not differ for cats that completed the study vs. those that did not ($p=0.44$). Also, owner-perceived QOL did not differ between cats that achieved ideal BCS (5/9) vs. those that did not achieve ideal BCS ($p=0.80$).

Visit	Eat & Drink (p=0.6547)	Engage/ Socialize (p=0.0073) *	Groom & Scratch (p=0.0002) *	Moving from One Point to Another (p=0.0001)*	Play & Hunt (p=0.0000) *	Rest & Observe (p=0.7389)	QOL Sum (p=0.0000)*
Initial Visit Mean QOL Score median (range)	6.0 (3.0-30.0)	12.0 (4.0-36.0)	20.0 (3.0-36.0)	24.0 (4.0-36.0)	18.0 (4.0-36.0)	18.0 (6.0-36.0)	110 (57.0-186.0
Final Visit Mean QOL Score median (range)	6.0 (2.0-30.0)	12.0 (5.0-36.0)	24.0 (4.0-36.0)	30.0 (5.0-36.0)	24.0 (6.0-36.0)	21.0 (6.0-36.0)	126.0 (79.0-210.0)

Table 3.4 Initial and Final Visit QOL Scores
Asterisk (*) indicates statistical difference

3.5.3 Physical activity

Cats physical activity data is not included in this thesis due to difficulty obtaining the data after repeated attempts to retrieve the accelerometer data from the company. Physical activity data will be included in the final published manuscript.

3.5.4 Low-Calorie Vegetable Consumption

Owners that reported disruptive food seeking behavior were offered low-calorie vegetable options (e.g. zucchini, green beans, cauliflower, lettuce, broccoli) to feed to promote satiety in their cats while continuing to limit energy intake. For cats who did not eat plain vegetables (table 3.5), a palatant was added[1].

	Cats Fed Vegetables + Palatant	Cats Fed Plain Vegetables	Cats Not Fed Vegetables
% cats (n=44)	63.6% (n=28)	9.1% (n=4)	27.3% (n=12)

Table 3.5 Vegetable Consumption

3.6 Discussion

To our knowledge, this is the first study assessing owner-perceived QOL in obese cats fed via a food toy versus a food bowl. The pilot study suggested the food toy used in the current study was a practical method for owners to offer food and provided a positive experience. Furthermore, the monthly questionnaire adapted from Benito et al. (2012) showed an increase in ability scores in 5 of the 6 activities.

The current study evaluated the effect of a food toy on owner-perceived quality of life of obese cats during a weight loss plan and determined the effect of a food toy on cat activity. During the initial visit, owners ranked the QOL items (eating and drinking, engaging in social activities with humans & pets resting and observing, grooming and scratching, playing and hunting, moving from one point to another) they considered most important for their cat's quality of life. The highest ranked QOL indicator was an inactive activity, 'eating and drinking', and the lowest ranked indicator was an active activity,

[1] Purina FortiFlora®

‘moving from one point to another’. Owners may correlate eating and drinking with QOL because decreased food intake is often associated with diminished health. Kienzle and Bergler (2006) reported owners of overweight cats more often utilized food rather than play as a method of treating compared to owners of cats with an ideal BCS. This can indicate the “food is love culture” extends to household cats and offering food items may be perceived as an important factor in the human-animal bond.

The results of this study indicate no difference was seen in perceived QOL scores between owners offering food via a food bowl versus a food toy. Food toy compliance was not 100% which likely affected QOL scores. Difficulty implementing the toy was reported as a result of a learning curve for the cats or difficulty separating the study cat from housemates during feeding. Owners reported variation in how the food dispensing toy was introduced which may have affected the cat’s ability to adapt to the food toy. Although, no difference in QOL scores was reported between groups, total QOL scores increased significantly for both study groups. QOL scores for ‘engaging/socialize’, ‘groom and scratch’, ‘move’, and ‘play and hunt’ increased significantly; thus, the primary drivers for increased QOL. A previous study reported an overall improved QOL score demonstrated as increase in mean vitality score, decreased in mean emotional disturbance, decrease in pain scores, but no difference in anxiety scores in obese dogs after weight loss (German et al., 2012). Improved QOL has also been demonstrated in obese humans with one or more co-morbidities undergoing a medical weight management program (Rothberg et al., 2014). Furthermore, obese men and women exhibited improved physical and mental composite measures characterized by improved physical functioning, general health, vitality, and mental health subscales after

completing a 6-month clinical weight management program (Blissmer et al., 2006). No difference in owner-perceived QOL was noted between cats successfully completing the study (lost 2 BCS and/ or reached ideal BCS) compared to those that were unsuccessful. This is in contrast to German et al. (2012) who reported improved QOL scores characterized by higher vitality and lower emotional disturbance scores in obese dogs successfully completing a weight loss program versus dogs that did not complete the weight loss program. The QOL findings in the current study may not fully reflect the difference in owner-perceived QOL at baseline compared to follow-up evaluations. After initial weight loss, multiple owners reported over scoring their cats' QOL at baseline, some of which were due to never previously having witnessed their cats with improved QOL. Thus, not acknowledging such an improvement as a possibility. This also may reflect some of the difficulty in quantifying owner perception of QOL in otherwise seemingly healthy cats. Although obesity is often linked to osteoarthritis in dogs and humans, one study indicated overweight cats were about five times more likely to develop lameness (J. M. Scarlett & Donoghue, 1998). Owners may be more likely to observe pain associated with osteoarthritis in dogs versus cats because of differences in owner-pet interaction. For example, pet owners are more likely to participate in active activities such as walking and running with their dogs and therefore may be more likely to appreciate lameness in dogs compared to cats. Distinguishing clinical signs of pain in cats can be more of a challenge. Cats are more likely hide when in pain and signs of pain can often be subtle (S. A. Robertson, 2005; Wright, 2002). Owners may be less likely to report lameness and therefore less likely to report a reduced QOL. The questionnaire utilized in this study is a general QOL questionnaire adapted from Benito et al. (2012)

and not specific to weight loss in cats. In a weight loss study involving overweight and obese adults, two generic and a single weight-related QOL measure were compared (Kolotkin et al., 2009). Greater improvement in QOL was noted when using the weight-related measure compared to the generic measures after the one-year weight loss trial and effect size differed amongst generic measures. A specific weight loss QOL measure may better capture QOL changes during and after weight loss.

Satiety can be an issue during weight loss. Increased food seeking behavior such as vocalizing, eating housemate's food, and opening cabinets to retrieve owner's food was reported. Such food seeking behavior resulted in lack of owner compliance e.g. feeding increased amounts of food. This study indicates low-calorie vegetables are a viable treat option to help maintain satiety in cats. Zucchini was a common vegetable suggested followed by broccoli, lettuce, spinach, cauliflower, and green beans to help maintain satiety. Vegetables were offered raw with the exception of one cat that indicated a preference for roasted zucchini. Most cats consumed vegetables only when combined with a palatant (Purina FortiFlora®). PurinaForti Flora was selected as a palatant due to its low-calorie content (four kcals per packet) and historic palatability. We suspect the 32 cats offered vegetables would have been pulled from the study due to disruptive food seeking behavior resulting in failure of the weight loss plan.

Feeding management is especially important when implementing a weight loss plan in a multi-pet household. Cats are less likely to lose weight and can potentially gain weight if access to a housemate's food source is not prevented. Feeding options such as offering foods in separate rooms, feeding non-overweight cats at a higher level such as on a shelf or table, and/or feeding the housemate inside a structure in which the overweight cat

cannot access. A controlled-access automatic feeder[2] was discussed and/or loaned to owners if the previously stated options were unsuccessful. A common complaint discouraging the purchase of such feeders was that they are cost prohibitive. However, four owners opted to purchase a feeder to discourage access to another pet's food.

Food toys are valuable methods of feeding for environmental enrichment. A single food toy (ball-style) was included in this study and did not appear to influence owner-perceived QOL. However, the role of food toys needs further investigation as there are several food toy styles that have not yet been investigated during a prescribed weight loss plan. Further investigation is needed to explore the relationship between food toys and other forms of environmental enrichment and owner-perceived QOL in cats undergoing a weight loss plan. Further investigation is necessary to develop a validated QOL questionnaire specific for cats undergoing weight loss.

3.7 Ethical Statement

The study protocol was approved by the Virginia Tech Institutional Animal Care and Use Committee (IACUC #16-068) and the Virginia Tech Institutional Review Board (IRB #16391).

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[2] PortionProRx (Vet Innovation, Inc ®

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3.8 Conflict of Interest

The authors have no conflict of interest to declare.

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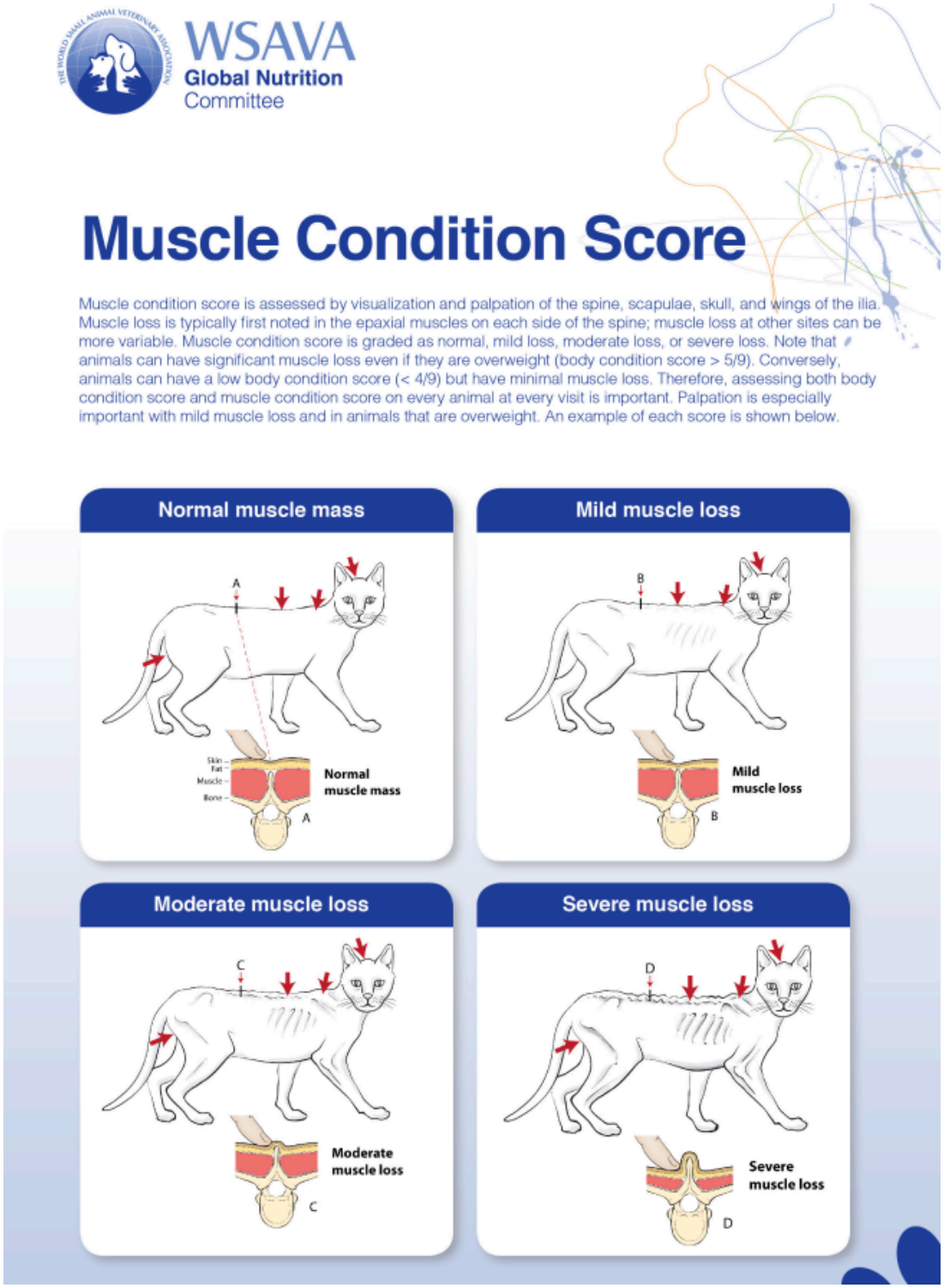
APPENDICES

Appendix A: 9- Feline BCS chart

Source: World Small Animal Veterinary Association
https://www.wsava.org/WSAVA/media/Documents/Committee%20Resources/Global%20Nutrition%20Committee/English/Cat-Body-Condition-Scoring-2017.pdf

Appendix B: Feline MCS Chart



Source: World Small Animal Veterinary Association
https://www.wsava.org/WSAVA/media/Documents/Committee%20Resources/Global%20Nutrition%20Committee/English/Muscle-Condition-Score-Chart-for-Cats.pdf

Appendix C: Initial Questionnaire

Cat Quality of life Questionnaire (Initial Questionnaire)

Please complete this questionnaire BEFORE your cat's weight loss plan.

1. Please **rank** the following actions in decreasing order based on what you believe are **important markers** for your cat's quality of life.

Rank (1 = most important; 6 = least important)	**Action**
	eating and drinking
	engaging in social activities with humans and pets
	grooming & scratching
	moving from one point to another
	playing & hunting
	resting & observing

2. Are there other 'actions'/behaviors that you believe are important markers for your cat's quality of life?

Appendix D: Monthly Questionnaire

Ability Questionnaire (Monthly Questionnaire)

Please complete the MONTHLY questionnaire DURING your cat's weight loss plan.

1. Circle the number that corresponds best to your cat's **ability to** do each action below; 6 = normal; 0 = impossible.

Action	Normal						Imposs-ible
eat & drink	6	5	4	3	2	1	0
engage in social activities with humans and pets	6	5	4	3	2	1	0
groom & scratch	6	5	4	3	2	1	0
move from one point to another	6	5	4	3	2	1	0
play & hunt	6	5	4	3	2	1	0
rest & observe	6	5	4	3	2	1	0

2. Has your cat's quality of life improved over the last month? YES NO

3. Have you observed your cat being more active over the last month? YES NO

4. If **yes**, how much more active?

10%	25%	50%	75%	100%
Eh, a little		Noticeable		Twice as active!