# FACTORS AFFECTING CANINE OBESITY IN EAST TENNESSEE SMALL ANIMAL VETERINARY PRACTICES

A Report of a Senior Study

by

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ABSTRACT

Canine obesity is a rapidly increasing health disorder that affects a majority of canine companions. The purpose of this study was to examine canine obesity in a rural and suburban veterinary clinic to examine the incidences between the clinics. In addition, this study investigated the etiologies of canine obesity. Surveys were collected at each respective clinic. Data analysis was conducted using SPSS software. A similar incidence of obesity was seen at each clinic, and over half of the total participants had a high BCS. A majority of the owner's (53-54%) inaccurately scored their pet's BCS. The spay/neuter status of the dog did not influence BCS ($p=0.37$), but females had a significantly higher BCS than males ($p=0.01$). A weakly positive correlation was identified between age of and BCS ($r^2=0.04$, $p=0.02$). No significant difference was seen when comparing the duration of the daily activity ($p=0.86$), but was seen in the mixed activity and walking activity groups when compared to BCS ($p=0.04$). A majority of canines received extra caloric intake daily, establishing a significant association with high BCS ($p=0.0001$). A weak positive correlation was noted between the canine's BCS and the number of undesirable behaviors ($r^2=0.13$, $p<0.0001$). The results of this study concluded some of the most common environmental influences of canine obesity in this area such as: owner perspective, sex, type of activity, extra caloric intake, and age. An additional correlation was identified between obesity and undesirable behaviors, like food begging,

barking, aggression, etc. This investigation has many potential future impacts, such as the influence of the human-animal bond, the influence in the quality of the food, effect of age at gonadectomy, and the relationship concerning undesirable behaviors and obesity.

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# CHAPTER I

# INTRODUCTION

## Background of Obesity Prevalence

Obesity is a growing health concern in domesticated canines and felines among veterinary professionals, and is considered to be the number one nutritional issue in pets (Hamper, 2016). The obesity epidemic affects a multitude of pets and has rapidly increased over the past half a century. In 1970, the prevalence of canine obesity was reported to be 28% (Mason, 1970), whereas in 2007, the Association for Pet Obesity Prevention (APOP) reported that 53% of cats and 43% of dogs were overweight or obese (APOP, 2007). As of 2018, it reported that 60% of cats and 56% of dogs were either overweight or obese (APOP, 2018). Not only is this disorder a concern in the United States, but it is also a global concern due to the increasing prevalence (Flanagan et al., 2017). Researchers in Spain determined that 40.9% of the dogs studied were obese (Montoya-Alonso et al., 2017), whereas incidences in China (Mao et al., 2013) and the UK (German et al., 2018) approach 50%.

## Categorization of Canine Obesity

Obesity is defined as a buildup of excessive amounts of adipose tissue in the body. The storage of fat is caused by either an excessive caloric intake, or a reduced caloric output (Hamper, 2016). Traditionally, the extent of canine and feline obesity is

quantified by a scale known as the body conditioning score (BCS). There are two different scales that can be used to categorize a pet's weight. One scale ranges from 1-5, while the other scale ranges from 1-9 (see Appendix 1). To determine a pet's BCS score, veterinarians feel and look at 4 different aspects of the body: the ribs, tailbone, sideview, and overview of the pet. When observing these specific aspects of a pet's body, veterinarians look at the amount of fat covering the ribs and the tailbone. The ability to palpate these areas, along with the amount of tuck in the abdomen seen from both views, is how a pet is categorized when compared to the BCS scale.

While the BCS scale is the most common method used, there are other ways to determine a pet's weight category (Mawby et al., 2004). Laboratory methods, such as dual-energy X-ray absorptiometry (DEXA) and deuterium oxide ($D_2O$) dilution, have also been used to determine the body composition of a pet. DEXA uses X-rays at two different angles to differ between the amount and the type of tissue in the scans. On the other hand, deuterium oxide dilution is a technique that measures the amount of total body water which provides an indirect measure of fat-free body mass. In comparison to clinical methods, like the BCS point scale and morphometric measurements, DEXA and deuterium oxide dilution methods are almost as accurate; however, due to accuracy, cost, and time efficiency of the laboratory methods, the body conditioning score has concluded to be the most reliable method.

Impact of Obesity on Pet's Health

Not only does the body conditioning point scale categorize the pet by weight, but it can also correlate with the pet's overall health. BCS is often utilized as a management tool to evaluate nutritional conditions. In addition to the BCS, the point to where a pet's health is

negatively impacted is also determined by the pet's actual weight. A pet is labeled as obese if the body weight exceeds the body size by 15% or more (Yam et al., 2016). A high rank on the body conditioning point scale, which is anything above an ideal body type, can often be associated with causing harm to the pet's health (Ockert, 2015), and excessive fat storage has been shown to cause a multitude of adverse health issues in canines (Table 1). In addition to multiple organ system complications, obese pets have shown to exhibit a decreased function in their immune system, increasing their risk at contracting serious secondary infections (German, 2006). The severity of the diseases and symptoms associated with pet obesity tend to worsen as the pet ages (Frye et al., 2016). Indeed, the life expectancy of an obese pet diminishes tremendously, and morbidity is often a result of severe obesity (Czirjak and Chereji, 2008).

In addition to detrimental health outcomes, pet obesity is also associated with deterioration of the quality of life. Pets that are considered to be overweight or obese have shown a lower quality of life when compared to pets that are considered to be ideal (Yam et al., 2016). Aspects that play a role in this decreased quality of life are vitality, increased pain, and emotional disturbance (Linder and Mueller, 2014). Interestingly, it was determined that overweight and obese pets are more prone to display undesirable behaviors like food stealing, food aggression, barking at other dogs, aggression towards strangers and familiar people, fearfulness, and separation anxiety (German et al., 2017).

Table 1. Health issues associated with pet obesity.

| Health issue | Specific Health Issue | Reference |
|---|---|---|
| Cardiorespiratory disease | Hypertension, tracheal collapse, Brachycephalic airway obstruction, laryngeal paralysis, respiratory compromise | Czirjak and Chereji 2008; Bastien et al., 2014; German, 2016; Lund et al., 2006; Mizelle et al., 1994 |
| Endocrine disorders | Hyperadrenocorticism, Hypothyroidism, diabetes mellitus, insulinoma, hypopituitarism, hypothalamic lesions | Czirjak and Chereji 2008; German, 2006; Kil, 2010; Lund et al., 2006; Zoran, 2010 |
| Metabolic disorders | Hyperlipidemia, dyslipidemia, insulin resistance, glucose intolerance, metabolic syndrome | Czirjak and Chereji 2008; German, 2006; Lund et al., 2006; Zoran, 2010 |
| Urinary tract disorders | Urethral sphincter mechanism incompetence, calcium oxalate urolithiasis | Czirjak and Chereji 2008; German, 2006; Lund et al., 2006 |
| Reproductive disorders | Pyometra, ovariohysterectomy, dystocia | Czirjak and Chereji 2008; German, 2006; Krook et al., 1960; Lund et al., 2006 |
| Neoplasia | Mammary, transitional cell carcinoma | Czirjak and Chereji 2008; German, 2006; Lund et al., 2006 |
| Orthopedic diseases | Osteoarthritis, inflammation, intervertebral disk disease, joint disorders | Czirjak and Chereji 2008; Frye et al., 2016; German, 2006; Lund et al., 2006 |

Etiology of Canine Obesity

Canine obesity can be caused by genetic, nutritional, exercise, pharmacological, and pathogenic influences (Sclafani, 1984). Obesity is considered to be a polygenic disorder heavily influenced by environmental conditions (Hamper, 2016). A deletion in certain genes has been shown to have a positive relationship with increased body conditioning scores (Raffan et al., 2016). This gene deletion was shown to be more prevalent in obesity-prone breeds, like Labrador retrievers. Breeds with genetic predispositions to obesity include Cairn Terriers, Cavalier King Charles Spaniels, Scottish Terrier, Cocker Spaniel, Border Collie, Labrador Retriever, Golden Retriever, Pug, Jack Russell Terrier, English Bulldog, and most crossbreeds (Yam et al., 2016). These breeds are more susceptible to rapid weight gain at a young age, increasing the odds of developing obesity as an adult (German, 2016). Due to the fact that these breeds are prone to developing obesity, it is considered to be inherited. Breeding standards increase the prevalence of obesity by selectively breeding pedigree dogs that have specific desired traits along with the predisposition factors to obesity (Asher et al., 2009). Breeding practices have also caused an increase in inherited defects, harming the health of these breeds. Interestingly enough, Sighthound breeds seem to be resistant to developing obesity (Byers, 2011).

One of the most obvious environmental factors contributing to obesity is the nutrition of the pet. This entails the nutritional value of the food, the quantity of the food, how often the pet is consuming the food, and if the pet receives additional sources of nutrition like table scraps and treats (German, 2006). A dog that is fed outside an ideal diet has the potential to develop obesity (Schlotthauer, 1941). Based on age, breed, and target size of the pet, an ideal diet contains sources of energy such as: amino acids, glucose precursors, fatty acids,

minerals, vitamins, carbohydrates, proteins, fats, salts, and water (National Research Council, 1985). Suitable resources may come from plant, animal, and synthetic products. Additional sources of energy are common in domesticated canines, like table scraps and treats, and have been correlated to excess weight gain (Heuberger and Wakshlag, 2011). In addition to a lack of nutrients, table scraps and treats typically exceed the caloric input threshold. While the nutritional value of the pet's diet is related to weight gain, it does not predispose the pet to obesity (German, 2006). Instead, the amount of food consumed and the number of meals given daily has a stronger relationship to obesity.

The most common ingredients in canine food are corn, soybeans, rice, and potatoes. Over half of commercial dog food contains these additives that have been identified to be genetically modified, also known as GMO. It was recently determined that animals on a genetically modified ingredient diet tended to become overweight when compared to animals on a non-GMO based diet (Foss 2012). GMOs have also been found to lower the nutritional value of the food that contains it. Although recent research has indicated that GMO additives in dog food may increase the risk of obesity, the mechanism through which this occurs has not been determined. More research should be conducted in this subject.

Another cause of obesity is a deficiency of calories burned caused by a lack of exercise. Not only does insufficient exercise cause weight gain, but the pet decreases in lean body mass (Sandoe et al., 2014). This sedentary lifestyle and obesity can be related to the relationship between the pet and owner. One of many components the owner and pet relationship is the owner's perspective (German et al., 2017). The owner's awareness of the pet's condition has shown to have a huge impact on the development of obesity and the ability to achieve a healthy life. A majority of the owners that have an obese pet see it in a

way that inhibits the ability to see the pet's genuine condition. These owners often see the pet as a baby and feel guilty for denying food begging behavior. This perspective is a gateway for a sedentary lifestyle for the pet.

The age and health of the owner is an additional component that plays a major role in the pet obesity epidemic (Courcier et al., 2010). As the age of the owner increases, there is a higher risk for the pet to gain weight. There is also a positive relationship between the health of the owner and the incidence of pet obesity. It has been seen that an overweight individual is more likely to have an overweight pet. This is primarily related to the fact that the owner is not as able to exercise with their pet, resulting in excess weight gain for the pet. Likewise, a low income of the owner negatively impacts the pet, as the pet is more likely to become obese due to the fact that the owner is financially incapable of obtaining the preventive health resources such as: healthy diet, toys for exercise, and medications.

Infections are an additional cause of obesity (Dhurandhar, 2001). These infections, termed as infectobesity, are induced by particular pathogens (Table 2). The production of adipose tissue is involved with the regulation of the immune response to the pathogens. Chronic inflammation is part of the immune response that occurs (Perez de Heredia et al., 2012). Obesity has been seen to have ties with an upregulation of leptin and a downregulation of adiponectin, in turn inducing inflammation in the body and affecting immune cell function. This positive feedback loop in turn alters the metabolic function, allowing for the development of canine obesity.

Another component that is associated with canine obesity is the neuter or spay status of the pet (German, 2006). This correlation is explained by a decrease in metabolic function, after a neuter or spay is performed on the pet, which is indirectly caused by altering sex

hormones. These sex hormones are decreased which directly affects the satiety center of the pet's brain by changing leptin and ghrelin levels (Byers, 2011). The pet's required daily caloric intake may need to decrease after this procedure (Linder and Mueller, 2014). This need may not be acknowledged by the owner, resulting in weight gain for the pet. Age is another aspect associated with pet obesity (Czirjak and Chereji, 2008). The incidence of pet obesity begins to increase once a pet has reached sexual maturity (2 years of age) and becomes more prominent as the pet reaches an advanced age (6-8 years).

Medications for preexisting conditions are another possible factor that can increase a pet's risk for developing obesity (Byers, 2011). Certain medications that are prescribed for a preexisting conditions have the potential side effect of increased weight gain. Phenobarbital, an anti-convulsant, has been known to raise serum concentrations and cause polyphagia. Glucocorticoids promote abdominal lipogenesis and gluconeogenesis. The condition for which the pet is medicated  may also in turn cause weight gain. Among these conditions, hypothyroidism and Cushing's disease have been verified to be a cause of canine obesity.

The gut microbiome of an obese dog has been seen to be contrastingly different when compared to a healthy dog (Kieler et al., 2017). Different gut microbiomes were found to impact the rate to which weight is lost in an obese pet. This varying rate is due to the amount of energy the gut of absorbs from the diet. During the development of obesity in canines, there is an alteration in the abundance of specific taxa present in the gut that promote adiposity by initiating a higher absorption of nutrients (Ley et al., 2005).

Table 2. Pathogens that induce obesity.

| Pathogen | Remarks | References |
|---|---|---|
| Canine distemper virus | The initial viral impact in the hypothalamus initiates changes that continue to promote obesity throughout the pet's life | Bernard et al., 1999; Dhurandhar, 2001 |
| Rous-associated virus-7 | RAV-7 produced fat deposits and fat pad, and decreased thyroid function. | Carter et al., 1983; Dhurandhar, 2001 |
| Borna disease virus | BDV infection is characterized by lympho-monocytic inflammation of the hypothalamus, hyperplasia of pancreatic islets, and elevated triglyceride and serum glucose levels. | Dhurandhar, 2001; Gosztonyi and Ludwig, 1995. |
| Scrapie agent | Function of obesity-promoting characteristic dependent on an effect of scrapie on the hypothalamic-pituitary-adrenal axis. | Dhurandhar, 2001; Kim et al., 1988. |
| SMAM-1 avian adenovirus | SMAM-1 causes excessive visceral fat production and lower levels of serum lipids. | Dhurandhar et al., 1990; Dhurandhar, 2001 |
| Human adenovirus Ad-36 | Ad-36 increases adipose tissue and lowers serum cholesterol and triglyceride levels | Dhurandhar et al., 2000; Dhurandhar, 2001 |

Treatment of Canine Obesity

Once a pet is diagnosed with obesity, veterinarians suggest treatment options in attempts to better the pet's health and its overall quality of life. These treatment options differ on a case by case basis. Of these numerous options, veterinarians can elect to treat canine obesity by diet and exercise. None of these treatment options would succeed without the instructions of a weight loss plan and the compliance of the owner.

Treatment plans begin by predominately targeting one of the most common risk factors which is the pet's diet (Flannagan et al., 2017). This is achieved by substituting the current diet with a diet-formulated food prescribed by the veterinarian. Contrasting from common commercial dog food, therapeutic dog food is formulated to provide a balanced diet, to support a healthy weight, to ease the digestion process, and to obtain a maximum amount of nutritional value. Therapeutic dog foods do not contain high amounts of salt or fat like commercial dog food (see Table 3). Along with the low-fat, low-calorie diet, these specialized foods include a beneficial source of fiber which promotes satiety and indirectly eliminates food-begging behavior (German, 2016). The amount of food given is also shortly decreased to less than the required maintenance amount to invoke successful weight loss. In addition to changing the pet's diet quality and quantity, other outside sources of nutrition should be eliminated like table scraps and treats. These extra sources of nutritive value combat the goal of weight loss by increasing the caloric intake and opposes what is seen to be a healthy diet. Another viable option is to modify the treats given to the pet instead of excluding treats altogether by immensely decreasing the amount of the treat and the caloric value of the treat.

Table 3. A nutritional comparison of different types of dog food brands.

| Nutrients in Dog Food Brands | | | |
|---|---|---|---|
| Nutrients | Gravy Train | Purina One[1] | Hills[2] |
| Crude protein (%) | 17 | 26 | 24 |
| Crude fat (%) | 8 | 16 | 9 |
| Crude fiber (%) | 4 | 3 | 15 |
| Calcium (%) | 0.60 | 1 | 0.6 |
| Phosphorus (%) | 0.50 | 0.8 | 0.55 |
| Potassium (%) | 0.60% | - | - |
| Zinc (mg/kg) | 110 | 150 | - |
| Sodium (%) | 0.25 | - | - |
| Chloride (%) | 0.40 | - | - |
| Vitamin C (mg/kg) | - | - | 115 |
| Vitamin E (IU/kg) | - | 250 | 540 |
| Vitamin A (IU/kg) | - | 13,000 | - |
| Moisture (%) | - | 12 | - |
| Linoleic Acid (%) | - | 1.4 | - |
| Selenium (mg/kg) | - | 0.35 | - |
| Glucosamine (ppm) | - | 350 | - |
| Omega-6 Fatty Acids (%) | - | 1.6 | - |

[1] Purina One Smart Blend
[2] Hills Prescription Diet: Metabolic Weight Management

Exercise is another treatment option veterinarians consider to combat canine obesity. Suitable exercises include those like walking, swimming, hydrotherapy, and treadmills (German, 2006).This approach to weight loss aids in the development of a healthy lifestyle. Not only is this exercise something that is beneficial to the pet, but the owner can too part take in exercising with the dog (Sandoe et al., 2014). This option has been deemed successful if strictly used due to the fact that the pet is burning off the excess energy buildup in its body. Increased exercise paired with a change of the pet's diet is an extremely successful way to achieve weight loss in the pet.

While there are currently no pharmaceutical agents on the market that veterinarians can prescribe for canine obesity, there have been various drugs previously used in veterinary medicine, but have been discontinued due to either adverse side effects or ineffective results (Table 4). Additionally, carnitine is an agent that has been identified to reduce weight of an obese companion and is now incorporated into widely-used dog foods due to its beneficial properties (Center et al., 2000). Other vitamin supplements have the potential to possibly promote weight loss.

Successful weight loss would not be able to occur without the creation of a weight loss plan and the consistent determination of commitment. To achieve successful weight loss, complete cooperation from both the pet and the owner are required. Failure of successful weight loss typically can be a result of a lack of owner cooperation (Remillard, 2001). Owner perspective and an established understanding is an integral component that is detrimental to ensuring weight loss success. Another crucial aspect to creating a successful weight loss plan is for the veterinarian and the owner to anticipate future obstacles such as owner motivation, finances, pet compliance, and monthly weight check-ins (Loftus and Wakshlag, 2014). A

clear plan will aid in ensuring the pet progresses towards achieving the target weight and determine which treatment option will be best for the patient.

While a traditional plan is the typical method of weight loss, a new protocol has been tested and deemed more effective. Partial weight loss is a distinct method that alters the definition of the target weight to be between the pet's current weight and ideal weight (German, 2016). This method has been seen to increase the rate of successful weight loss by implementing a more attainable goal for the owner and pet, which indirectly increases the compliance of the clients. When the first target goal is obtained relatively quickly, a new goal can be set that is closer to the pet's target weight until the pet reaches the ideal weight.

Table 4. Pharmaceutical agents previously used for treating canine obesity.

| Medication | Assessment of Drug | Reference |
|---|---|---|
| Slentrol (dirlotapide) | Ineffective in weight reduction. | McRee, 2009 |
| Amphetamines | Causes excitement, hypothermia, agitation, and convulsive episodes resulting from intoxication poisoning. | Stowe et al., 1976; |
| Dinitrophenol | Results in harmful side effects like hypothermia, significant acute toxicity, and death | Grundlingh et al., 2011 |
| Hormone and peptide supplements | Ineffective in weight reduction | Gossellin et al., 2007 |
| Laxatives and Amylase Blockers | Not used due to amount of malnutrition and nutrient deficiency | Gossellin et al., 2007 |
| Phenylpropanolamine | Ineffective in weight reduction | Kushner et al., 2002 |
| Sucrose Polyester | Adverse side effects like vitamin deficiency | Thomason et al., 1998 |

## Management and Prevention of Canine Obesity

In summary, maintaining weight loss includes a continuation of a healthy diet and sufficient exercise for the pet. Exercise alone has been shown to prevent rapid weight gain that can occur after any successful weight loss (German, 2006). Diets in the management of obesity are altered to limit the energy contribution while maintaining a normal amount of nutritive elements. In addition to this, the pet should be fed the appropriate quantity required for a healthy weight (Czirjak and Chereji, 2008). Regular weight checkups are also recommended by veterinarians to raise awareness of the pet's ongoing condition.

After successful weight loss, a multitude of improvements can be noted in the pet's condition. Clinically, weight loss has been identified to enhance respiratory function, insulin sensitivity, mobility, and relieve associated orthopedic diseases (German, 2016). The overall quality of life of the pet improves so drastically that its life could potentially be expanded by multiple years due to the weight loss.

The basic principles of appropriate nutrient intake and routine exercise apply to the prevention of canine obesity as well . It is suggested that puppies should weigh-in monthly to observe their growth rate, and best predict their target adult weight. Monthly weight checks can also aid in the acknowledgement of how to alter the pet's feeding regimen as it develops.

## Purpose

The purpose of this experiment is to assess the most common etiologies of canine obesity in a suburban small animal veterinary clinic in Maryville, Tennessee, in addition to a rural small animal clinic in Benton, Tennessee. The obesity incidence, corresponding etiologies, and subsequent effects will be compared to identical variables in healthy canines.

# CHAPTER II

# MATERIAL AND METHODS

At Chilhowee Veterinary Clinic in Maryville, Tennessee, 77 surveys were collected from privately owned canine patients at this facility. Bishop Animal Hospital, in Benton, Tennessee, collected 78 surveys from their canine patients. Of these surveys, 75 were used for Chilhowee Veterinary Clinic, and 74 were used from Bishop Animal Hospital. Some surveys were discarded due to either a lack of pertinent information or the pet did not meet the age requirements for this study. All canines of one year in age or older qualified for this study. All dogs varied in breed and age (see Appendix 6). This study was designed to assess the incidence of canine obesity individually and comparatively for each clinic and to determine the underlying environmental causes and consequential effects of canine obesity.

## Incidence of Canine Obesity

For 5 consecutive months, canine obesity was observed at Chilhowee Veterinary Clinic in Maryville, Tennessee and at Bishop Animal Hospital in Benton, Tennessee by recording each canine's body conditioning score (BCS) on a scale from 1-5 (Appendix 1), with any score over a 3 considered overweight/obese. Prior to data collection, the methodology for this experiment was approved by Maryville College's Institutional Review

Board (Appendix 2) and Institutional Animal Care and Use Committee (Appendix 3). Canine-owning clients were asked to voluntarily participate in this experiment and each client gave his/her written consent (Appendix 4). Each canine's breed, neuter status, and age were noted by method of a survey to determine the most prominent factor(s) for canine obesity in the clinic (Appendix 5). The survey also noted other variables including the dog's current diet, amount of food given, exercise practices, owner perspective, and behavioral changes. Once all of the surveys were retrieved from both clinics, each survey received a unique identification number to anonymously put them into Excel for further analysis.

Statistical Analysis

The incidence of canine obesity for both the rural and suburban clinic were individually calculated by method of descriptive statistics to determine the percentage of ideal, overweight, and obese canines. Reliability of owner perspective was estimated by observing the pet's BCS compared to the owner's hypothesized BCS. The total amount of owners that did/did not correctly categorize their pet's BCS was tallied. SPSS software was used to statistically analyze the data. BCS was compared to both neuter status and sex using a two-tailed ANOVA and Tukey HSD Post Hoc analysis. A one-way ANOVA and Tukey HSD Post Hoc was used to analyze the influence of the pet's exercise activity and duration on the BCS between clinics. The influence of age on BCS was assessed using a linear regression analysis. To compare the feeding activity to the BCS, a two-tailed t-Test assuming equal variance was conducted. A regression analysis was conducted to determine the correlation between BCS and undesirable behaviors in canines.

# CHAPTER III

# RESULTS

## Demographics

Breed distribution of both Chilhowee Veterinary Clinic and Bishop Animal Hospital was observed (Appendix 6). The average age of each breed is shown in correspondence. The mean sex and neuter status of the participating canines for each clinic is shown in Table 5.

Table 5. Total amount of male and female canines, in addition to the total amount of intact and spayed/neutered canines in each the rural and suburban clinic.

| | Total Females | Total Males | Total Intact | Total Neutered/Spayed |
|---|---|---|---|---|
| CVC | 35 | 40 | 7 | 38 |
| BAH | 44 | 30 | 68 | 36 |

## Incidence of Canine Obesity

The majority of participating canine clients at Chilhowee Veterinary Clinic and Bishop Animal Hospital had a body condition score of overweight or obese (Table 6). Over half of the owners viewed their pet's BCS as being ideal, whereas in fact their pet's veterinarian assigned BCS was higher than the owner's perspective at both Chilhowee Veterinary Clinic (53%) and Bishop Animal Hospital (54%). Of the total 149 canines, the spay/neuter status of the pet did not significantly influence the BCS ($p=0.37$, Figure 1).

However, sex and BCS score did show significance, with females having higher BCS scores than males (see Figure 2; $p=0.01$). Additionally, older dogs appeared to have a significantly higher BCS ($p=0.02$, $r^2=0.04$; Figure 3).

Exercise activity influenced BCS, specifically in the groups of a mixed activity and walking activity ($p=0.038$, Figure 4A). However, daily duration of exercise was showed no statistical difference (Figure 4B; $p=0.864$). Another influential factor observed was if the pet received extra food. The amount of pets in this study that received treats and table scraps amounted to be 86% (Figure 5). Of the 86%, well over half of the pets were overweight or obese, having an overall significant influence on the pet's BCS ($p=0.0001$, Figure 6). A weak positive correlation ($r^2=0.13$) between the number of undesirable behaviors and BCS was statistically significant ($p<0.0001$, Figure 7). The behaviors were ranked based on number of incidence (Table 7).

Table 6. Incidence of overweight and obese canines, in Chilhowee Veterinary Clinic and Bishop Animal Hospital, compared to the accuracy of the owner's perception.

| | Chilhowee Veterinary Clinic | Bishop Animal Hospital |
|---|---|---|
| Ideal Weight (%) | 33 | 31 |
| Overweight (%) | 45 | 54 |
| Obese (%) | 20 | 15 |
| Owner Perspective Accuracy (%) | 47 | 46 |

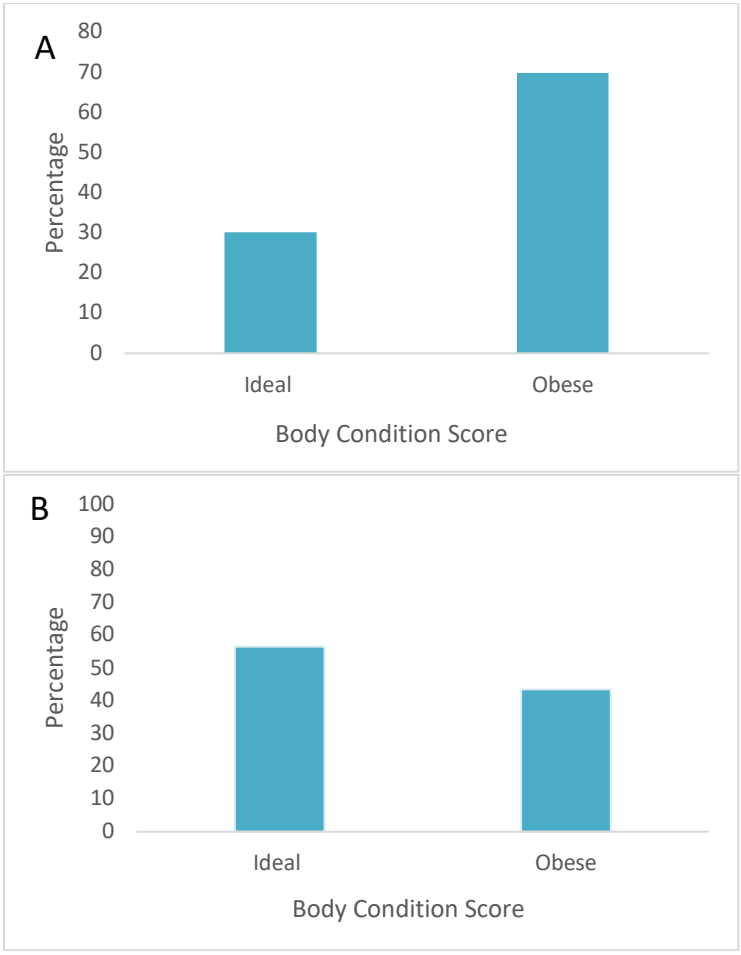


Figure 1. Spay/neuter status compared to BCS combining the rural and suburban clinic (p=0.366). A) The percentage of spayed and neutered pets that have an ideal BCS (30%) compared to the percentage that had a high BCS (70%). B) The percentage of intact male and females that have an ideal BCS (57%) versus the percentage with a BCS of overweight or obese (43%).

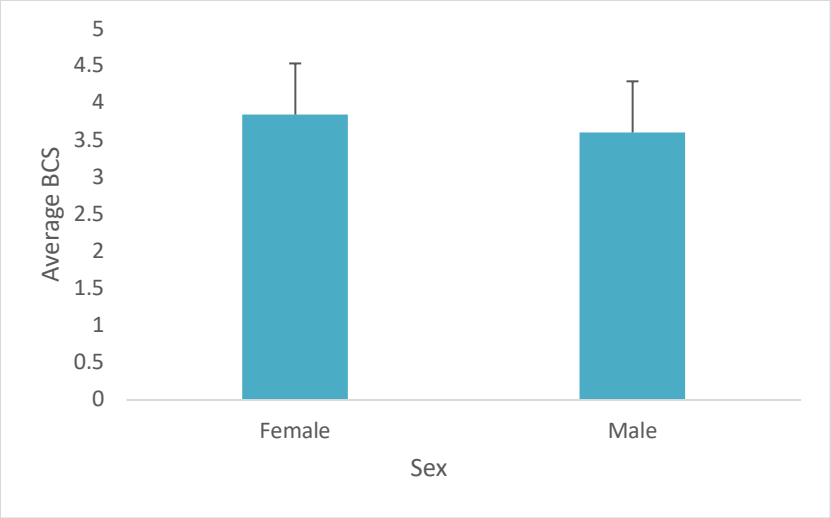


Figure 2. Mean BCS (+1 SE) comparing male and females from both clinics. Females have significantly higher BCS compared to males (p=0.01).

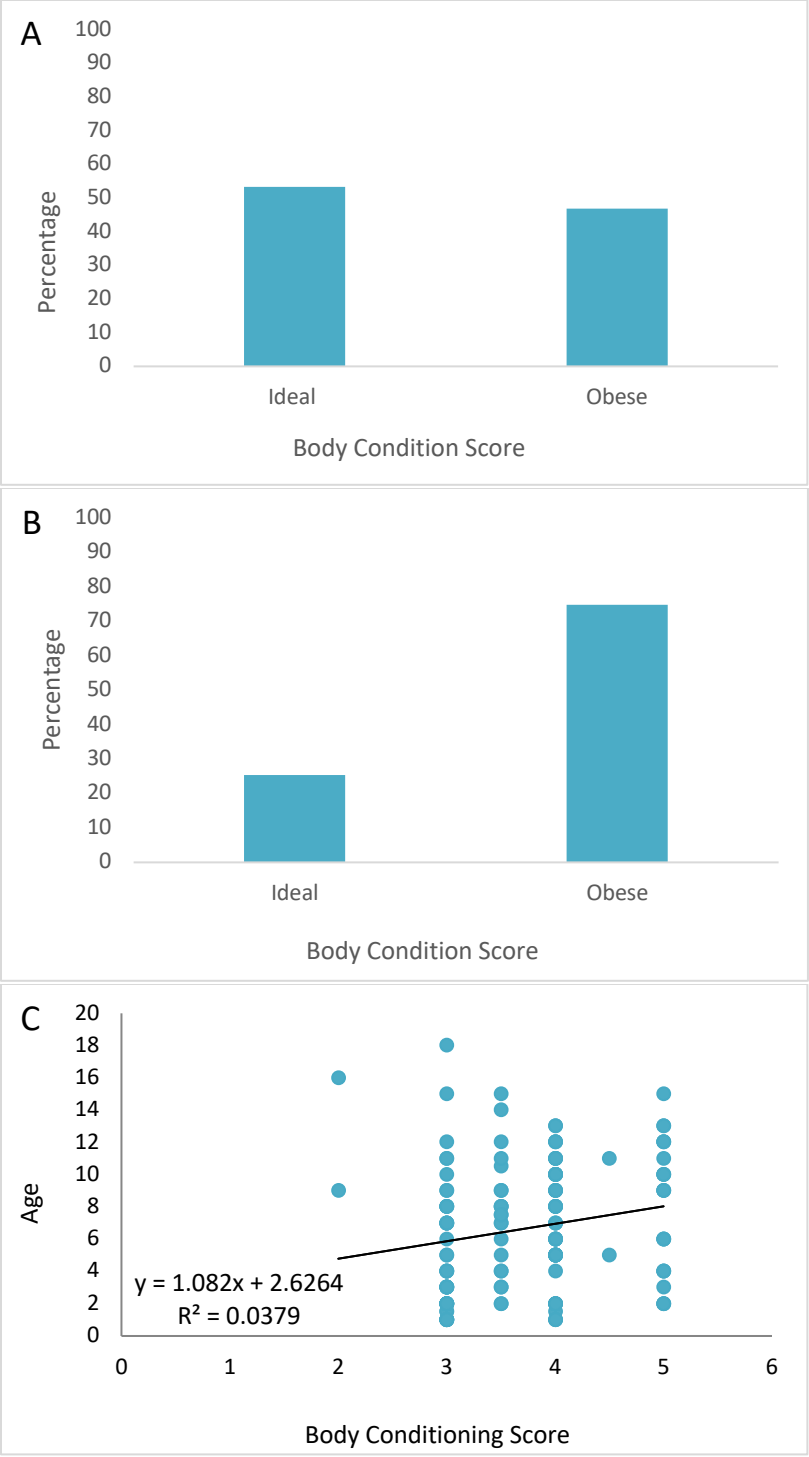


Figure 3. Graphical representation of the significant influence of age on the BCS of canines in the rural and suburban clinics. A) The percentage of young pets (under the age of 6 years old) that have an ideal BCS (53%) versus the percentage of canines with a BCS score of overweight or obese (47%). B) The percentage of senior canine patients (6 years of age or older) that scored a BCS of 3 (25%) compared to the percentage that were overweight or obese (75%). C) A weak positive correlation between age of the pet compared to the BCS ($r^2$=0.04, p=0.02).

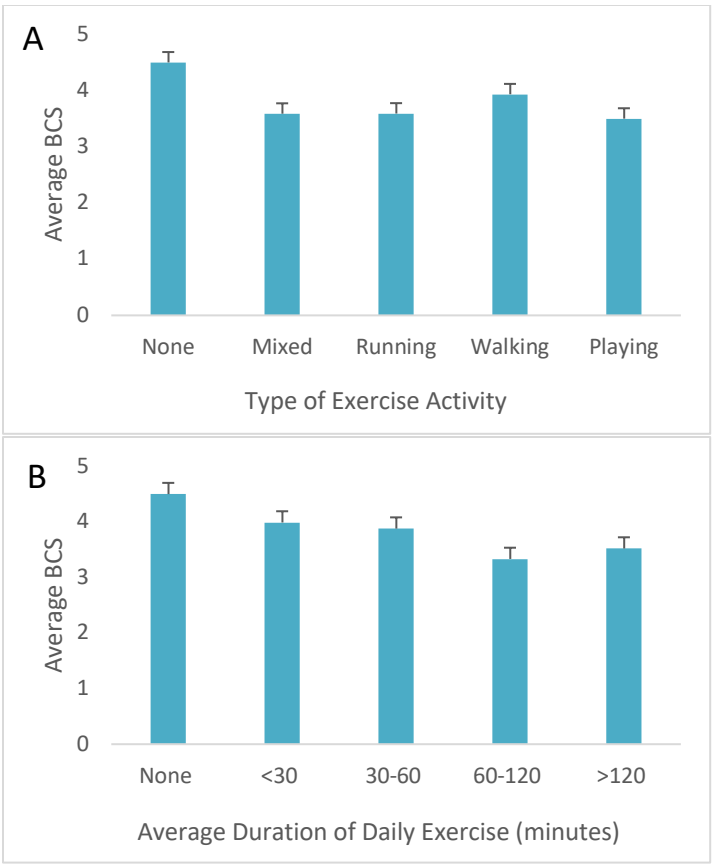


Figure 4. A) Mean BCS (+1 SE) compared to type of exercise activity. A statistical significance was found between the mixed activity and walking activity (p=0.038). B) Mean BCS (+1 SE) compared to amount of daily activity (p=0.864).

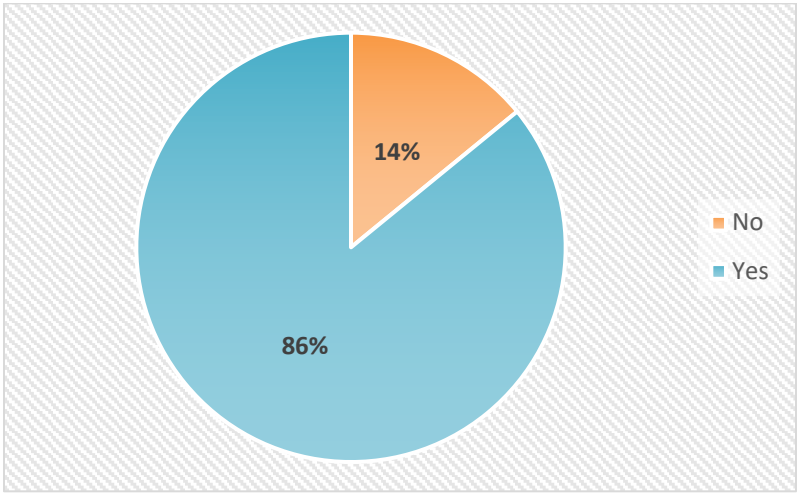


Figure 5. Percentage of canine participants that did receive extra treats and/or table scraps versus the percentage of pets that did not. Of the pets that do receive treats and/or table scraps (86%) compared to the minority that do not (14%).

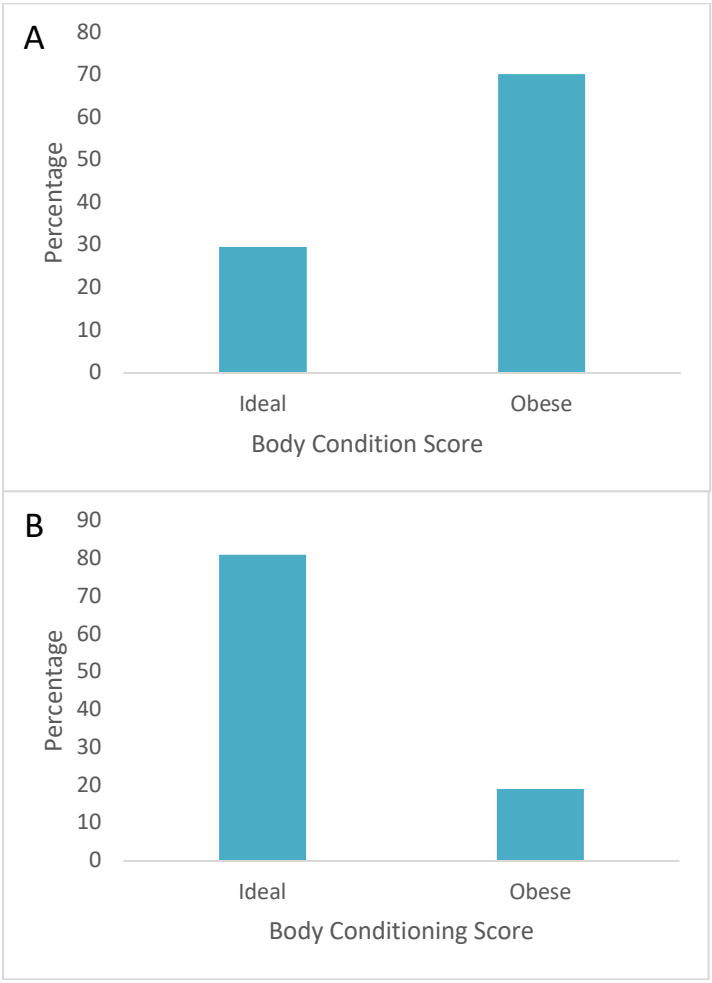


Figure 6. Data representation of the amount of canines from each clinic that receive extra caloric intake having a significant relationship with the BCS (p=0.000115). A) Of the pets that receive extra caloric intake 70% were scored to have a high BCS, while the 30% that receive treats remained to have an ideal BCS. B) Of the pets that did not receive treats or table scraps, 81% had an ideal BCS, while the remaining 19% had a high BCS

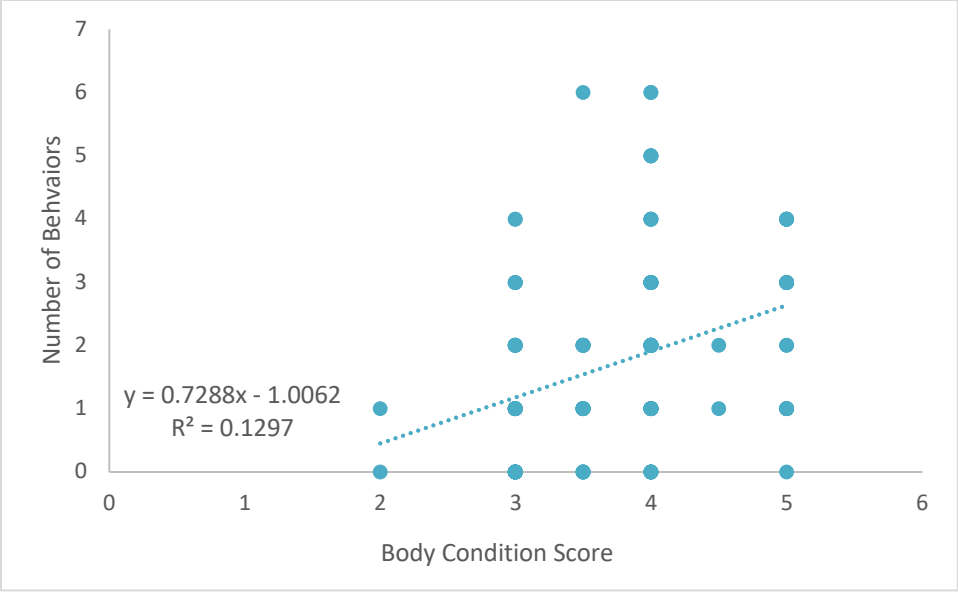


Figure 7. A weak positive correlation between the number of behaviors displayed compared to the BCS ($r^2$= 0.13, p<0.0001).

Table 7. Each behavior observed in this study ranked from the highest number displayed to the lowest number displayed.

| Type of Behavior | Count of Behavior |
|---|---|
| Food Begging | 90 |
| Barking/Biting/Growling | 58 |
| Aggressive Towards Animals | 33 |
| Aggressive Towards Strangers | 28 |
| Food Aggression Towards Animals | 28 |
| Aggressive Towards Familiar People | 8 |
| Food Aggressive Towards People | 4 |

# CHAPTER IV

# DISCUSSION

The results of this study show that there was no significant difference in the incidence of canine obesity between a rural and suburban small animal veterinary clinic. A majority (between 53-54%) of owner perspective was found to be inaccurate. While the spay/neuter status was observed to not influence the BCS, the sex of the pet did significantly influence BCS. A significant, weak positive correlation was discovered between the age and BCS of the participants. The pets that participated in a mixed or strictly walking activity had a lower BCS compared to the other activity groups, meaning the BCS reflects the type of activity. However, the daily duration of activity did not affect BCS. A significant relationship was found between the amount of pets that received extra caloric intake, like treats and table scraps, and a high BCS. Furthermore, a significant, weak positive correlation was found between the number of undesirable behaviors and BCS.

## Factor of Owners

Over half of the canine owning clients that participated in this study inaccurately scored their pet's BCS, scoring it as ideal when in fact the pet was overweight or obese. These results support those of previous studies. An owner's assigned BCS can be significantly higher than the veterinarian's, concerning the pet's BCS; in fact, the owner's

often provide narratives to explain their dog's BCS (White et al., 2011). Most owners are unaware of their pet's declining health regardless of an informative session with their veterinarian that compared the pet's BCS directly to a chart (Eastland-Jones et al., 2014). Owners who did not consider obesity to be a disease were more likely to own obese dogs (Munoz-Prieto et al., 2018). In addition, the owner's attitude to diet and exercise lead to obesity in themselves and could increase their pet's risk of developing obesity. Other variables that the owners may have on canine obesity, like age, education level, and income, were not investigated in this study, but has been noted as an influencer of canine obesity from previous research (Courcier et al., 2010). An additional association of the human-animal interaction as an influencer of canine obesity is the parenting style of the owners. An authoritative parenting style had the highest number of overweight/obese canines, while an authoritarian parenting style had the lowest percentage (Herwijnen et al., 2018). Overhumanizing of canines has also been indicator of the human-animal interaction as an influencer of pet obesity (Kienzle et al., 1998). There is an association between the owner's view of their pet, in terms of humanizing, when compared to their BCS.

Spay/Neuter Status and Sex

The BCS of the canines did not correlate with their neuter status, but females were concluded to be at the highest risk of developing obesity. This is in contrast to past research studies that determined canines that have been spayed/neutered are more likely to have a high BCS when compared to intact canines (Courcier et al., 2010). A more recent study determined that neutering/spaying increases the risk of obesity in male canines, but not female canines (Bjornvad et al., 2019). Another considerable factor is the age at which a pet

is spayed/neutered, in terms of its influence on obesity development, but was concluded that the timing of the procedure did not influence onset of obesity ( Lefebvre et al., 2013). The findings that females are at an increased risk for developing canine obesity supports other research. Courcier and colleagues stated that fat accumulation over time is more common in females than in males (2010), and this supports our findings.

Other Environmental Factors

Age is another environmental factor that was associated with the development of canine obesity in East Tennessee clinics. These findings are supported by previous studies (Mason, 1970; Courcier et al., 2010). As in humans, aging tends to be accompanied by a reduction of the basal metabolic rate (Shimokata et al., 1993), and this decrease in metabolic rate is a plausible underlying mechanism.

Another environmental factor that influenced canine obesity is exercise. In this study, it was concluded that the activity type, like a mixed activity and strict walking, did influence the pet's BCS; however, the duration of the activity did not. This is contrary to past research that stated that obese pets are exercised for a shorter duration when compared to dogs with a normal BCS (Bland et al., 2009). In comparison, activities that required larger amounts of exercise significantly affected the pet's BCS (Mao et al., 2013). Activities that consist of more agility, like a mixed activity and walking, burn off a higher number of calories which is used by the body for energy. This allows for the body to reach the caloric goal for maintenance and caloric deficit for weight loss. Using feeding toys increases daily activity by 12% and daily walking activity by 26% (Su et al., 2019). This may be an effective tool for weight loss programs to encourage an increase in activity.

Extra caloric intake is another environmental factor is influences the onset of canine obesity. The results of this study concluded there was a significant relationship between the number of pets receiving table scraps and treats and a high BCS. These findings support similar findings in pas studies (Mao et al., 2013). A link between feeding habits and the human-animal bond has been noted as a potential risk factor of canine obesity (Kienzle et al., 1998). The owners of obese dogs had less interest in a balanced nutrition and frequently purchased lower-priced food when compared to the normal dogs. Additionally the type of ration was no different between the two groups. Contrastingly, pets that received daily treats and snacks were not at an increased risk of being overweight (Courcier et al., 2010).

Behavioral Findings

A significant correlation between a pet's BCS and the number of undesirable behaviors was found. A dearth of research in this area leads to numerous unanswered questions. The plausible answer may be an underlying health condition causing the pet to gain weight and have undesirable behavior in response to pain or fear. For instance, canines that had a higher concentration of total thyroxine (T4) hormones in dogs with behavioral problems, suggesting that an alteration in thyroid function or metabolism may occur in some canines with obesity and/or behavioral issues (Carter et al., 2009). A correlation between parenchymal Aβ deposits and behavioral problems in older canines (Colle et al., 2000). This alludes to the ideology that behavioral problems could be a symptom of a more serious health issue.

## Conclusion

An observation of risk factors associated with canine obesity in two East Tennessee small animal veterinary practices allowed for a renewed perspective concerning this rapidly increasing disease. Understanding the mechanisms of the factors that influence the onset of canine obesity holds value in research as many future applications may investigate similar etiologies. For instance, future studies could focus on the human-animal bond and interaction to determine different risk factors and develop more effective owner-involved treatment methods. Future research concerning other environmental factors like the time of spay/neuter affecting the development of obesity in adult years. Another area of future research could inspect how the type of dog food (brand, dry versus wet, etc.) influence canine obesity. Additionally, due to a lack of information on the behavioral aspect of canine obesity, more studies need to be conducted to better understand the relationship between the two and any underlying factors.

# APPENDICES

APPENDIX 1: BODY CONDITION SCORE (BCS) CHART USED TO CATEGORIZE A PET'S WEIGHT ON A 5 AND 9 POINT SCALE (AAHA 2010).

# Body Condition Scoring (BCS) Systems

| 5 Point | 9 Point | Description |
|---|---|---|
| 1/5 | 1/9 | **Dogs:** Ribs, lumbar vertebrae, pelvic bones and all bony prominences evident from a distance. No discernible body fat. Obvious loss of muscle mass.  **Cats:** Ribs visible on short-haired cats; no palpable fat; severe abdominal tuck; lumbar vertebrae and wings of ilia obvious and easily palpable.  |
| 1.5/5 | 2/9 | **Dogs:** Ribs, lumbar vertebrae and pelvic bones easily visible. No palpable fat. Some evidence of other bony prominence. Minimal loss of muscle mass. **Cats:** Shared characteristics of BCS 1 and 3. |
| 2/5 | 3/9 | **Dogs:** Ribs easily palpated and may be visible with no palpable fat. Tops of lumbar vertebrae visible. Pelvic bones becoming prominent. Obvious waist.  **Cats:** Ribs easily palpable with minimal fat covering; lumbar vertebrae obvious; obvious waist behind ribs; minimal abdominal fat.  |
| 2.5/5 | 4/9 | **Dogs:** Ribs easily palpable, with minimal fat covering. Waist easily noted, viewed from above. Abdominal tuck evident. **Cats:** Shared characteristics of BCS 3 and 5. |
| 3/5 | 5/9 | **Dogs:** Ribs palpable without excess fat covering. Waist observed behind ribs when viewed from above. Abdomen tucked up when viewed.  **Cats:** Well proportioned; waist observed behind ribs; ribs palpable with slight fat covering; abdominal fat pad minimal.  |

| 5 Point | 9 Point | Description |
|---|---|---|
| 3.5/5 | 6/9 | **Dogs:** Ribs palpable with slight excess fat covering. Waist is discernible viewed from above but is not prominent. Abdominal tuck apparent. **Cats:** Shared characteristics of BCS 5 and 7. |
| 4/5 | 7/9 | **Dogs:** Ribs palpable with difficulty; heavy fat cover. Noticeable fat deposits over lumbar area and base of tail. Waist absent or barely visible. Abdominal tuck may be present.  **Cats:** Ribs not easily palpable with moderate fat covering; waist poorly distensible; obvious rounding of abdomen; moderate abdominal fat pad.  |
| 4.5/5 | 8/9 | **Dogs:** Ribs not palpable under very heavy fat cover, or palpable only with significant pressure. Heavy fat deposits over lumbar area and base of tail. Waist absent. No abdominal tuck. Obvious abdominal distension may be present. **Cats:** Shared characteristics of BCS 7 and 9. |
| 5/5 | 9/9 | **Dogs:** Massive fat deposits over thorax, spine and base of tail. Waist and abdominal tuck absent. Fat deposits on neck and limbs. Obvious abdominal distention.  **Cats:** Ribs not palpable under heavy fat cover; heavy fat deposits over lumbar area, face and limbs; distention of abdomen with no waist; extensive abdominal fat pad.  |

AAHA

APPENDIX 2: INSTITUITIONAL REVIEW BOARD (IRB) RESEARCH APPROVAL.

Maryville College

Maryville College Institutional Review Board
OHRP IRB#: IRB00007383
FWA Assurance #: FWA00015150

**Principal Researcher: Heather Ellis**

**Faculty Supervisor: Dr. Drew Crain**

**Division: Natural Sciences**

**Title: Assessment of Canine Obesity at Local Veterinary Clinic**

**Protocol# 240219.01**

**Approval Status: Approved under Exemption 2**

March 5, 2019

Dear Heather:

The Maryville College Institutional Review Board (IRB) has carefully considered your proposal referenced above. The proposed procedures afford reasonable protection to the human participants involved and therefore you are granted approval for the study.

Your approval is effective March 5, 2019 and will expire one year from this date. Thereafter, continued approval is contingent upon submission of a progress report that must be reviewed and approved prior to the expiration date.

Approval is contingent upon your agreement to obtain informed consent from your participants, to abide by the protocol summarized in the approved IRB application, and to keep appropriate records concerning your participants.

You are required to submit to the Maryville College IRB for review any changes in procedures involving human participants prior to the implementation of such changes.

If you have any questions concerning this approval or regulations governing human participant activities, please contact Ryan Mickey, Chair of the Maryville College IRB, by e-mail at IRB.Review@maryvillecollege.edu or by phone (865) 981-8262.

Sincerely,

Ryan Mickey

Ryan Mickey, Ph.D.
Institutional Review Board, Chair

502 E. Lamar Alexander Parkway, Maryville, Tennessee 37804-5907
Voice 865.981.8000 | Fax 865.981.8010 | maryvillecollege.edu

APPENDIX 3: INSTITUITIONAL ANIMAL CARE AND USE COMMITTEE (IACUC) RESEARCH APPROVAL LETTER.

**MARYVILLE COLLEGE INSTITUTIONAL ANIMAL CARE & USE COMMITTEE**
**Application for Use of Vertebrate Animals in Student Research**

*Provide information after each bold item*
**Student Name:**
**Heather Ellis**
**Student Email Address:**
**heather.ellis@my.maryvillecollege.edu**
**Date:**
**2/14/19**
**Senior Study Advisor:**
Dr. Crain
**Species to be used:**
**Canines**
**Age of animals:**
**varies**
**Number of animals in study:**
**TBD**
**Duration of study:**
**April 1, 2019-September 1, 2019**
**Location of animals during the study (building and room):**
**Chilhowee Veterinary Clinic**

**List personnel to call if problems with animals develop:**

| Name | Daytime Phone | Nighttime Phone | Emergency No. |
|---|---|---|---|
| Mark Steeley | (865)9776598 | N/A | N/A |
| Heather Ellis | (423)7167865 | N/A | N/A |

**What will happen to the animals at the end of the study? If euthanasia is required, state the specific methods.**
The animals in this study will not be harmed, sedated, or euthanized for the purpose of this study. The pets will come into the clinic with their owner, the owner will fill out a survey, and leave after their appointment.

*(Do not write below line: For MC IACUC Use)*

Maryville College IACUC Approval Number: 201904
Date Approved: 3/7/19
Signed: Dr. Rebecca Crain

APPENDIX 4: INFORMED CONSENT PORTION OF SURVEY.

**Maryville College Senior Thesis Assessment of Canine Obesity in a Local Clinic**
**Human Participant Consent Form**

1. This research will investigate the relationship between canine obesity and what causes it. Participants in our studies will complete surveys that will allow us to collect data on pet obesity.

2. Chilhowee Veterinary Clinic clients that own dogs will be asked to fill out the survey when the pet is presented for an annual health exam.

3. This survey will ask questions about the pet's diet and exercise trends, as well as the owner's perspective and the pet's behavior.

4. There are no foreseeable risks for you or your pet.

5. There are no costs for participating.

6. One expected benefit of this research is a greater knowledge of the factors that contribute to pet obesity. Each participant will receive an explanation of the research being conducted.

7. We are interested only in aggregate data. No report of the project will contain data that can be identified with any individual participant. Records will be kept in secure storage at the clinic and all data will be stored in a secure laptop.

8. For questions about the research, contact Heather Ellis (principal investigator) or Dr. Drew Crain (faculty advisor):

**Drew Crain**
**Maryville College**
**502 E. Lamar Alexander Pkwy.**
**Maryville, TN 37804**
**Drew.crain@maryvillecollege.edu**

**Heather Ellis**
**Maryville College**
**502 E. Lamar Alexander Pkwy.**
**Maryville, TN 37804**
**Heather.ellis@my.maryvillecollege.edu**

9. You have rights as a research volunteer. **Taking part in this study is completely voluntary. If you do not take part, you will receive no penalty. You may stop participating at any time without penalty.** If you have questions about your rights as a research volunteer that I have not addressed, you may write the Chair of the Maryville College IRB:

**Internal Review Board**
**Maryville College**
**502 E. Lamar Alexander Pkwy.**
**Maryville, TN 37804**
**Irb.review@maryvillecollege.edu**

I have read and understood the information above. I consent to take part in this study. The researchers have answered my questions to my satisfaction. I understand a copy of this form is available upon request.

Participant's Signature _____ Date _____

Heather Ellis
Investigator's Signature

3-21-2019
Date

**PLEASE COMPLETE THE SURVEY ON THE BACK OF THIS FORM**

APPENDIX 5: RESEARCH SURVEY ON CANINE OBESITY.

**Current Diet (specific brand and type):**_____.
**Amount of Food Given (circle one):**

½ c.(4 oz) 1 c.(8 oz) 1 ½ c.(12 oz) 2 c.(16 oz) 2 ½ c.(20 oz)3 c.(24 oz) 3 ½ c.(28 oz)
4 c.(32 oz) 4 ½ c.(36 oz) 5 c.(40 oz) 5 ½ c.(44 oz) 6 c.(48 oz) 6 ½ c.(52 oz)
other _____.

**How often do you feed your pet daily? (circle one):**

Once a day Twice a day Three times a day Other: _____.

**How did you choose your pet's food? (sales rep, veterinarian, price, ads, etc):**_____
_____.
**Supplements (treats, table scraps, etc. and how often given):**_____.
_____.
**How is your pet fed? (circle all that apply):**

Free feed Controlled feed Shared with other household pets Toys Other:_____.

**Exercise activity:**_____.
**Exercise duration:**_____.
**Exercise frequency:**_____.
**How do you see your pet's weight? (circle one):**

Underweight Thin Ideal Overweight Obese

**Has your veterinarian ever discussed your pet's weight with you?** Y / N
**Has your pet ever shown any of these behaviors (circle all that apply):**

Food aggression towards other animals
Food aggression towards humans
Aggressive towards other animals
Aggressive towards strangers
Aggressive towards familiar people
Barking/ Biting/ Growling
Food begging behavior

---

**VETERINARIAN USE ONLY**

**Dog's name:**_____ **Dog's breed:**_____.
**Dog's weight:**_____ **Dog's BCS (1-5):**_____.
**Sex: M / NM** **Age:**_____.
**F / SF**

APPENDIX 6: DEMOGRAPHIC DATA OF CANINE PARTICIPANTS FROM BOTH CLINICS.

| Breed | CVC | BAH | Mean Age (years) |
|---|---|---|---|
| Australian Cattle Dog | 2 | 0 | 4.5 |
| Australian Shepherd | 1 | 0 | 3 |
| Basset Hound | 0 | 1 | 5 |
| Beagle | 0 | 1 | 11 |
| Bichon Frise | 0 | 1 | 9 |
| Bloodhound | 1 | 0 | 1 |
| Blue Tick Coonhound | 0 | 1 | 3 |
| Border Collie | 1 | 0 | 4 |
| Boston Terrier | 2 | 1 | 6.7 |
| Boxer | 0 | 1 | 7 |
| Cairn Terrier | 3 | 5 | 5.5 |
| Catahoula | 0 | 1 | 8 |
| Chihuahua | 7 | 3 | 9.6 |
| Cocker Spaniel | 1 | 1 | 7.5 |
| Collie | 1 | 0 | 8 |
| Dachshund | 3 | 2 | 6.8 |
| Doberman | 1 | 0 | 8 |
| Dutch Shepherd | 1 | 0 | 7 |
| Feist | 1 | 3 | 3.75 |
| French Bulldog | 1 | 2 | 4 |
| German Shepherd | 8 | 2 | 6.7 |
| Golden Retriever | 2 | 0 | 2.5 |
| Great Dane | 0 | 1 | 3 |
| Great Pyrenees | 1 | 0 | 1 |
| Labrador Retriever | 5 | 10 | 9 |
| Lhasa Apso | 1 | 0 | 11 |
| Maltese | 1 | 2 | 7.6 |
| Mastiff | 3 | 0 | 5.3 |
| Miniature Pinscher | 0 | 1 | 10 |
| Miniature Schnauzer | 2 | 0 | 6.5 |
| Mixed | 13 | 12 | 7.4 |
| Newfoundland | 1 | 0 | 1.5 |
| Parson Russell Terrier | 1 | 0 | 12 |
| Pekingese | 1 | 0 | 15 |
| Pitbull | 1 | 2 | 9.3 |
| Plott Hound | 0 | 2 | 3.5 |
| Pomeranian | 0 | 2 | 9 |
| Poodle | 1 | 2 | 10.3 |
| Pug | 0 | 6 | 5.3 |
| Redbone Coonhound | 1 | 0 | 6 |
| Shih Tzu | 1 | 0 | 7 |
| Spitz | 1 | 0 | 7 |
| Springer Spaniel | 1 | 0 | 10.5 |
| Staffordshire Terrier | 1 | 0 | 7 |
| Treeing Walker Coonhound | 0 | 2 | 7 |
| Weimaraner | 0 | 1 | 10 |
| West Highland Terrier | 0 | 2 | 6.5 |
| Vizsla | 1 | 0 | 8 |
| Yorkshire Terrier | 1 | 4 | 5.4 |

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