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CLINICAL, EPIDEMIOLOGICAL AND LABORATORY ASPECTS OF OBESITY IN DOGS AND ITS CORRELATION WITH SYSTEMIC DISEASES

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Abstract

The aim of this study was to identify the clinical, epidemiologic and laboratorial aspects of dogs with obesity and its possible correlation with other diseases. A total of 30 dogs were studied. Of these, 15 were obese and 15 were not. On the Control Group, there was a total of 10 females (5 neutered and 5 whole) and 5 males (all 5 neutered). On the Obese Group, 11 females (7 neutered and 4 whole) and 4 males (all 4 neutered). The tutors received a form with 12 questions about food management and physical activity, as well as pharmacological and family history. In addition, venous blood samples were collected in animals from both the Control Group and the Obese Group for a Complete Blood Count and dosage of biochemical levels (Alanine Aminotransferase, Alkaline Phosphatase, Albumin, Total Proteins, Urea, Creatinine). Measurements from the abdominal perimeter were taken and using the data the body fat percentage was calculated; an Electrocardiographic evaluation (ECG) was also made, along with the measurement of the systolic, diastolic and medium blood pressure (SBP, DBP and MAP, respectively) and heart rate (HR). The numeric data was submitted under the Analysis of Variance (ANOVA), followed by the Tukey's Test ($p<0.05$), while the data regarding risk factors was analyzed on a descriptive manner. In both groups, mixed-breed dogs had a significant predominance, about 9 (60%) on the CG and 7 (46.66%) in the Obese Group. Concerning food management, 12 (80%) of the subjects of the Control Group were fed at will and 3 (20%) once a day; the numbers on the use of only pet food, pet food coupled with homemade food, and only homemade food were, respectively, 10 (66.6%), 4 (26.6%) and 1 (6.8%). Also, 11 (73.3%) had frequent physical activities, while the other 4 (26.7%) only occasionally. Additionally, 12 (80%) stayed at the backyard, while 3 (20%) lived in an apartment. There was not any relevant data relating to pharmacological and family history and, according to tutors' opinions, their dogs were within the ideal weight. On the Obese Group, 8 (53.5%) were fed at will, 5 (33.3%) were fed on a strict and controlled manner, and 2 (13.3%) one time a day, while 9 (60%) of them were given both pet food and homemade food, 5 (33.3%) received only pet food and 1 (6.7%) received pet food sachets and fruit. In this group, 9 (60%) were out, 15 did not practice any type of physical activity, while 3 (20%) practiced frequently and the other 3 (20%) walked occasionally. There were 5 patients (33.3%) with a history of corticosteroid use, and 7 (46.7%) had a family history of obesity. Regarding tutors' opinions on their pet's weight, on whether they thought their pet was too thin, on ideal weight, overweight or obese, the data showed, respectively, 2 (13.3%), 4 (26.7%), 8 (53.3%) and 1 (6.7%). The percentage of fat on the Control Group for males and females was, respectively, 18.7 ± 2.2; 22 ± 3, while the abdominal circumference was of 63 ± 20 cm. On subjects from the Obese Group, the values were 40.4 ± 5; 45 ± 4.7 and 65 ± 16.8 cm, respectively. On laboratory exams, the Complete Blood Control did not show any inconsistencies with the normal range and the ALB and FAL were elevated on the Obese Group. The ECG did not show any notable changes. Both groups showed a slight increase in PAS (Control Group = 141 ± 27.72 mmHg; Obese Group = 142 ± 17.23 mmHg), and on the obese animals a raise in PAD (84 ± 22 mmHg) was also recorded. Obesity is a chronical disease that brings a series of bad consequences to the animal well-being, especially the appearance of systemic diseases; the main risk factor for its appearance is incorrect food management and low or nonphysical activity. The main way to prevent the disease is by the correct management of both factors.

Keywords: Fat. Diet. Disease. Canine. Risk factors.

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1 Introduction

Canine obesity is a pathological condition having physical and organic consequences caused by an excessive increase in weight and corporeal dimensions. The condition is triggered by changes in feeding, as a consequence of alterations in life conditions. Such alterations are due to a closer proximity with the tutor of the dog. Animals that were primitively carnivorous become omnivorous, with the inclusion of industrialized snacks and treats intended for human consumption, that are inadequate for the health of the animal. Industrialized rations of questionable quality become the main food offered to dogs, often having a, high content of salt, carbohydrates, and fat. Such inadequate feeding becomes associated with other factors, such as lack of control of the quantity of calories ingested and sedentarism. Under these conditions the animals tend to gain weight. This predisposes individuals to illnesses causing serious damage to health and to quality of life, and thus impairing the longevity of the dog.

Other non-nutritional factors are also indirectly responsible for weight gain, mainly factors related to race, sex, age, use of certain medications and endocrine disorders. These characteristics are responsible for causing changes and consequent decrease in metabolism. This decrease harms the anabolism and catabolism process of the animal organism. The body working more slowly causes weight gain and, in extreme cases, obesity.

Some body transformations resulting from obesity may originate several systemic illnesses. The morbidity condition is aggravated by conditions such as diabetes mellitus, hyperlipidemia, skin diseases, neoplasms, cardiovascular diseases such as arterial hypertension, orthopedic problems, and reproductive changes.

This study aims to identify and evaluate clinical, epidemiological and laboratorial aspects of obesity in dogs from the city of Patos, Paraíba. Canine patients received medical care at University Veterinary Hospital Prof. Dr. Ivon Macêdo Tabosa, of the Federal University of Campina Grande, and at Veterinary Center PetBem, located in the city of Patos, Paraíba. The physical condition of dogs was correlated to systemic illnesses that could compromise the well-being and quality of life of the animal.

2 Literature Review

2.1. Obesity in small animals

Obesity is a multifactorial illness, the various causes being termed risk factors. These are pathological or physiological conditions that predispose the organism to metabolic alterations such as excess storage or reduction of catabolism.

Obesity prevails in animals confined to apartments, with few options for physical activity, and in elderly animals, when compared to active and younger animals (BLANCA, 2017). Furthermore, small and medium-sized races, such as Cocker Spaniel, Dachshund, Pug, Chihuahua, Schnauzer Miniature and Poodle, are more predisposed to become obese (CASE et al., 2000; GUIMARÃES; TUDURY, 2006; APTEKMANN et al., 2014). Animals of larger size, such as Rottweiler, Golden and Labrador Retriever, according to the same authors, are also predisposed towards becoming obese in some of their life stages.

Debastiani (2018) noted that an animal is only clinically considered as being obese when its weight exceeds the ideal for its race by at least 15%. As with human beings, obesity in companion animals is one of the most common nutritional illnesses observed. It is related to a positive energetic balance, that is, when the animal consumes more calories than it expends. This causes an excessive accumulation of calories, and a consequent gain in weight. The quantity of food offered to the animal is thus directly linked to mechanisms of positive and negative energetic balance (BACKUS and WARA, 2016; DEBASTIANI, 2018).

Silva et al. (2017) indicate that the identification of an obese animal is made by detecting excess of subcutaneous fat and silhouette loss. Such characteristics are related to the daily composition and frequency of eating, amount of physical activity, sex, race, age, among other factors related mainly to the routines established by the animal tutor (BRUNETTO et al., 2011; APTEKMANN et al., 2014; SILVA et al., 2017; GOUVÊA et al., 2018).

Morbidity becomes a matter of concern, because dog owners tend to underestimate obesity, believing that their overweight pet is at its ideal weight, when not considered as underweight (LARSEN; VILLAVERDE, 2016; GOUVÊA et al., 2018). Another factor to be considered is the human culture of aesthetics, in which a high weight in animals is valued, being considered a measure of beauty and good life (BACKUS; WARA, 2016). As a consequence of excessive weight gain, the animal develops secondary physical and organic problems, such as skin diseases, mobility limitations, mainly articular, respiratory, endocrine, cardiovascular, and neoplastic ailments (BRUNETTO et al., 2011; DEBASTIANI, 2018).

2.1. Obesity in small animals

Excessive weight increase produces many metabolic alterations (OLIVEIRA; ZIMMERMANN, 2016; SANTOS, 2017). According to the listed authors, these changes reduce life span and worsen quality of life. Causes for weight increase are multifactorial, including prolonged periods of use of drugs, such as steroids, changes in the endocrine system, castration, sex, race, heredity, genetical factors, handling errors, among others.

2.2.1 Food management

Several factors of risk are involved, but the main factor causing obesity in dogs is attributed to errors in food management. Such errors often include providing rations of poor quality, giving food above the caloric necessity of the individual, and providing excessive food intended for human consumption, which is usually highly caloric (HALFEN et al., 2017). Furthermore, the palatability of the foods listed above act directly on weight increase, stimulating animals to east more, with stimuli from the hypothalamus. These food items are often rich is starch and fat, favoring the increase in weight, mainly when the animal already has a sedentary way of life. Under these conditions, size and frequency of meals becomes the decisive factor (CARCIOFI, 2005).

2.2.2 Sedentarism

Sedentarism represents a change in the original lifestyle of the dog and represents an adaptation to the lifestyle of its tutor (RIBEIRO; SOUZA, 2017). Under the evolutionary process of domestication, dogs gradually lost the habit of hunting, adopting home life in order to live intimately with their human owners. Such sedentarism causes an imbalance in the proportion of ingested and consumed calories, which favors a positive energetic balance and, consequently, obesity (PEREIRA NETO, 2009; SILVA et al., 2017; DEBASTIANI, 2018).

2.2.3 Genetic and hereditary factors

Ribeiro and Souza (2017) found that genetic and hereditary factors are responsible for the predisposition to develop ailments. Genome variations in different regions influence metabolites responsible for the storage of adipose tissue (TOLL et al., 2010).

It is usual to encounter clinical cases of obesity in animals belonging to several sizes and races, but predominating among smaller animals. Studies correlating obesity with race depend on where the research is conducted, because different races predominate in different regions. Such variability may mask or bias results. Aptekmann et al. (2014) found that 28% of dogs diagnosed as obese in Brazil did not belong to specific races. On the other hand, a similar study conducted by Colliard et al. (2006) in France found that 67% of cases of obesity belonged to some pure race, predominating in the race Labrador.

Sexual hormones act directly in diminishing or increasing metabolism. Non-castrated females have a lower metabolic rate than males. Debastiani (2018) found that young animals have a faster metabolism than more elderly dogs, which makes senior dogs more predisposed to develop obesity.

2.2.4 Castration

Neutered animals are more predisposed to develop clinical obesity than non-neutered ones. This is due to the decrease in basal metabolic rate, caused by the inhibition of sex hormones. This causes an occasional increase in sedentary lifestyle and appetite, and, consequently, stimulates a greater food consumption (RIBEIRO; SOUZA, 2017; PONTES et al. 2018). Metabolic reduction associated with castration is more commonly seen in females. Estrogen functions as an appetite inhibitor in normal animals (Debastiani, 2018).

2.2.5 Endocrinopathies

The most common endocrinopathies related to obesity in the clinic are hypothyroidism and hyperadrenocorticism. Hypothyroidism, an illness characterized by a low secretion of hormones T3 (triiodothyronine) and T4 (thyroxine) by the thyroid gland, may be of primary, or idiopathic, secondary, or tertiary origin. Less commonly, cases of neoplastic processes are encountered (CARCIOFI, 2005; ANTÔNIO; SANCHES, 2017; RAMOS, 2017).

Hormones T3 and T4, and mainly T4, act on all metabolic processes of the organism, mainly on the metabolism of proteins, carbohydrates, and lipids. A considerable portion of animals diagnosed with hypothyroidism are overweight, due to a low use of energy. Metabolism is low, without polyphagia (MONTANHA; LOPES, 2011; RAMOS, 2017).

Hyperadrenocorticism (HAC), also known as Cushing Syndrome, is another endocrine very common illness in dogs. It is caused by chronic exposition to corticoids, either by an imbalance increasing its endogenous production, or by an iatrogenic administration of glucocorticoids (BENEDITO; ROSSI; CAMARGO, 2017).

The endogenous production is caused by pituitary or adrenal changes, that entail unruly and independent production of adrenocorticotropic hormone (ACTH) and cortisol (ANTÔNIO; SANCHES, 2017). Research by Moura (2015) indicated that HAC is more common in dogs of small size of the races Yorkshire, Caniche Anão and Dachshund.

The change in the circulation of glucocorticoids alters the process of synthesis, storage and catabolism f carbohydrates, as well as stimulating the redistribution of fats in tissues and abdominal deposition (ANTÔNIO; SANCHES, 2017; MOURA, 2015).

2.2.6 Pharmacological

Some drugs are responsible for causing metabolic changes that favor the gain in weight. The drugs best known for these effects are the steroidal anti-inflammatory drugs or glucocorticoids, that are also produced endogenously by the adrenal glands. The glucocorticoids have hyperglycemic and hyperinsulinemia effect, and their prolonged use acts on the hypothalamus and adenohypophysis, inhibiting the endogenous secretion of glucocorticoids. The glucocorticoids are substituted and suppressed and supplied in an unbalanced way by remedies (ANTÔNIO; SANCHES, 2017).

Anticonvulsants, a group of drugs widely used in medical clinics, are also responsible for inducing increase in weight in animals, mainly because they induce polyphagia, the indiscriminate ingestion of food (SILVA et al., 2019).

2.3 Main complications

According to Brunetto et al. (2011) and Debastiani (2018), all transformations caused to the organism as a consequence of obesity end by causing several illnesses of a systemic nature. Morbidity becomes enhanced by ailments such as cardiovascular alterations, insulin resistance, hyperlipidemia, articular and respiratory alterations, reproductive failings, appearance of neoplasia, and changes affecting the urinary tract (PACKER et al., 2013; MARCHI et al., 2016; SANTOS, 2017; SILVA et al., 2017).

2.3.1 Cardiovascular alterations

The most commonly observed cardiovascular alteration in animals is arterial hypertension. The obese animal may develop cardiac autonomic neuropathy, a chronic illness in which an imbalance in the sympathetic and parasympathetic impulses of the autonomous nervous system of the heart occurs. Such an imbalance may produce a reduction in the parasympathetic tonus, and consequently induce the increase in the sympathetic tonus, provoking an increase in the cardiac frequency and, secondarily, an increase in the arterial pressure. Furthermore, an elevated secretion of angiotensinogen by the adipocytes promotes an elevation of angiotensin II, that acts directly on the kidneys. This promotes an increase in arterial pressure (CRANDALL et al., 1994; KLEIN et al., 2004; MARCHI et al., 2016).

2.3.2 Insulin resistance

One of the most important findings of research on the organic changes triggered by obesity is the fact that adipose tissue secretes adipokines, which act in various mechanisms of the body. Among these, are the processes of energy balance regulation and insulin sensitivity modulation, characterizing resistance conditions. These conditions are marked by persistent hyperglycemia, at the same time that there are high concentrations of insulin in the bloodstream. In Other words, despite the production of insulin, the cells are not able to respond to it correctly (MARCHI et al., 2016; SANTOS, 2016; SANTOS, 2017).

In elevated concentrations, the adipokines promote a great systemic impact. Adipokines participate in many physiological processes, such as the regulation of lipid and glycemic metabolism. They interfere in insulin sensitivity and are directly related to inflammatory processes.

Obesity also predisposes the organism to developing diabetes mellitus. It affects glucose transporters in cell membranes and reduces the sensibility of cell receptors for the hormone insulin (JERICÓ; KOGIKA; ANDRADE NETO, 2015). Obesity can thus be considered an illness of low intensity, of a chronic inflammatory character, associated to resistance to the action of insulin, and to hyperglycemia. It thus represents a metabolic syndrome (SANTOS, 2017).

2.3.3 Hyperlipidemia

According to Peixoto et al. (2010), lipid disorders are quite common in veterinary medical routine, especially in dogs. Among many factors, hyperlipidemia is a consequence of pre-established systemic imbalances, such as obesity. An increase in serum concentrations of lipids is observed. The most relevant lipids, clinically speaking, are cholesterol and triglycerides. Lipemic serum also interferes with the reading of biochemical tests (BRUNETTO et al., 2011).

2.3.4 Changes in the joints

Excess weight causes difficulties in mobility. This may oblige the dog to readapt its pacing to its body profile. They tend to give shorter and slower paces in order to absorb impacts. Excess weight exerts a great pressure on articulations, causing inflammation or, in advanced cases, degeneration problems. Furthermore, obesity is a factor of risk for illnesses such as hip dysplasia, osteoarthritis, and intervertebral disc disease (KEALY et al., 2010; PACKER et al., 2013).

A study in humans indicates that the severely obese have a higher incidence of pain in the knees than non-obese people. Individuals with body mass index >50 have a higher progression rate in arthrosis than individuals with body mass <50 (MARTINS et al., 2018).

2.3.5 Respiratory changes

Not only obesity, but also overweight represents risk for the development of illnesses in the respiratory tract. These conditions may aggravate and develop the syndrome of the brachycephalic, chronic bronchitis, and tracheal collapse. Furthermore, the animals present an increase in respiratory and cardiac rates, culminating in low lung activity (KLEIN et al., 2004; SPAULDING, 1992).

2.3.6 Reproductive failures

Obese bitches have a higher risk of developing infertility, of producing smaller litters, or of provoking neonatal death. They are more predisposed to dystocia when compared to non-obese individuals. The accumulation of fat in the pelvic cavity makes it difficult for the fetus to pass. In obese males a reduction in testosterone concentration, and quality of spermatozoa, occurs (SILVA et al., 2017; DEBASTIANI, 2018).

2.3.7 Skin diseases

According to Yosipovitch, Devore and Dawn (2007) and Debastiani (2018), obese patients have more conspicuous cutaneous folds. As a consequence, they retain more heat, due to the thick layer of fat, that generates overheating. These factors increase friction and moisture, which explains the higher incidence of skin diseases in obese patients.

Debastiani (2018) found that among the complications correlated with obesity are the presence of some kind of skin disease – specifically oily skin, desquamation, allergy, and dermopathy.

2.3.8 Neoplasms

In Human Medicine, obesity is one of the factors related to the appearance of tumors (VASCONCELOS; HORTA; LAVALLE, 2013). According to Harvey, Lashinger and Hursting (2011), some obesity biomarkers have been described. It has been observed that these were responsible for promoting the growth of neoplastic cells in humans and animals. As examples are hyperinsulinemia, leptin, sex hormones, pro-inflammatory cytokines, reduction in the concentration of adiponectin, a hormone that modulates glycemic regulation and fatty acid catabolism, and other metabolic processes.

Lauby-Secretan et al. (2016) state that neoplasms commonly related to obesity in humans are breast, thyroid, multiple myeloma and digestive tract neoplasms (colon and rectum, liver, gallbladder, pancreas, stomach and esophagus). In dogs, there is a prevalence of mast cell tumors, breast tumors, and transitional bladder cell carcinomas (WEETH et al., 2007; ALENZA et al., 2000). Silva (2018) complements that obesity is a risk factor for the development of bladder tumors. The fatty tissue may serve as a deposit for carcinogenic substances.

2.3.9 Urinary tract disorders

The main changes in the urinary tract are caused by the installation and activity of pathogenic bacteria (OLIN; BARTGES, 2015). Excess weight, as mentioned, tends to reduce – in some cases drastically – the quantity and frequency of daily physical activities, inducing, as a consequence, reduction in mobility. This favors the adhesion of microorganisms in the mucosa of the bladder, causing cystitis (MARSHALL et al., 2009; DEBASTINI, 2018).

2.4 Diagnosis

Although obesity is a worrying evil for tutors, most dog owners do not know that their animals are above weight (LAFLAMME, 2006). Rodrigues (2011) informs that several methods and equipment are used for the analysis of the corporeal condition of human beings. Yet this same equipment are little used in Veterinary Medicine, due to their high cost. Veterinary procedures are basically restricted to experimental methods.

In animals, diagnosis is done mainly with semiological methods of palpation and inspection. When inspecting an animal, one must distinguish deposition of abdominal fat from other situations that cause bulging, such as hydroperitoneum. An animal without palpable ribs, with a distended abdomen and a great quantity of adipose tissue at the base of the tail and inguinal region has weight in excess (RODRIGUES, 2011).

The Body Mass Index (BMI) is a practical method widely used that is very precise for diagnosis. It consists in a calculus that provides the adequate weight relative to corporeal mass, and follows the equation proposed by Rodrigues (2011) and Silva et al. (2019): [BMI = weight (Kg) / stature^2 (m)].

The Body Condition Score is a subjective method of corporeal evaluation, that defines the animal's score on a numerical scale from 1 to 9. Laflamme (2006) indicated that the ideal score is 5, and each number above this ideal represents an increase in weight of 15% to 20% away from the optimum. For example, an animal with a Body Condition Score of 7 has a percentage of body fat (% Control Group) from 20% to 30% more fat that is appropriate. Obese individuals score between 6 and 9 (APTEKMANN et al., 2014). Thus, Body Condition Score also permits an estimation according to the scale proposed by Laflamme (2006) (Table 1).

Table 1. Estimated values by percentage (%) of body fat based on the Body Condition Score 5 for dogs of male and female sex.

BCS	% Fat Male	% Fat Female
5	17	20
6	22	26
7	26	31
8	31	37
9	35	43

BCS: Body Condition Score.
Source: Adapted of Laflamme (2006).

It is possible, however, not only to estimate the values of fat percentage in animals, but also to obtain more precise results, and consequently closer to reality, using the equations propose by Burkholder and Toll (2000), where:

$$\% \text{ Control Group (M)} = \frac{[-1.4 \text{ (distance from patella to calcaneus)} + 0.77 \text{ (abdominal circumference)} + 4]}{\text{Body weight}}$$

$$\% \text{ Control Group (F)} = \frac{[-1.7 \text{ (distance from patella to calcaneus)} + 0.93 \text{ (abdominal circumference)} + 5]}{\text{Body weight}}$$

According to Burkholder and Toll (2000), animals with values between 16% and 25% of fat are considered to be within normality. Animals with % in the Control Group below 5% have cachexia, those with values between 5% and 15% are thin, above 25% and up to 35% are overweight, and those above 35% are represented by obese individuals.

Morphometry is used to measure the thickness of the skinfold, and thus of the adipose tissue deposited below the skin. According to Laflamme (2006), the abdominal circumference is the most indicated measurement for this evaluation.

3 Material and Methods

This project was submitted and approved by the Ethics Committee for Research ("Comissão de Ética no Uso de Animais") of the Center of Rural Technology of the Federal University of Campina Grande (UFCG/Brazil), under protocol n. 112/2018 (Appendix 1).

3.1 Animals and study site

Thirty dogs, including males and females, were evaluated, in fasting, without regard to race and sex. The animals were distributed into two groups (N=15), designated as Obese Group, containing obese animals, and Control Group, containing non-obese animals.

3.2 Evaluated parameters

3.2.1 Epidemiological data

Of the 30 animals, 20 were examined in the section of the Medical Clinic for Small Animals of the Veterinary Hospital Prof. Dr. Ivon Macêdo Tabosa, at Federal University of Campina Grande (HVUIMT/UFCG). The other 10 animals were examined at the private Veterinary Center Pet Bem. Both clinics are located in the city of Patos-Paraíba.

Data were collected in order to identify possible factors of risk for the animals used in this study. A previously prepared questionnaire with 13 items was developed for this aim, and applied to the tutors.

3.2.2 Identification of obesity and body score

Following the method proposed by Laflamme (2006), for measuring subcutaneous fat of each individual, a measuring tape was used to record the abdominal circumference. Next, the distance between the patella and calcaneus was measured and the animals were weighted. With this data, the equation proposed by Burkholder and Toll (2000) was applied.

The values were used to compare obese and non-obese animals. The final numerical value was correlated with the remaining data obtained for each animal. To evaluate the body score, the proposal of Rodrigues (2011) was used (Figure 1).

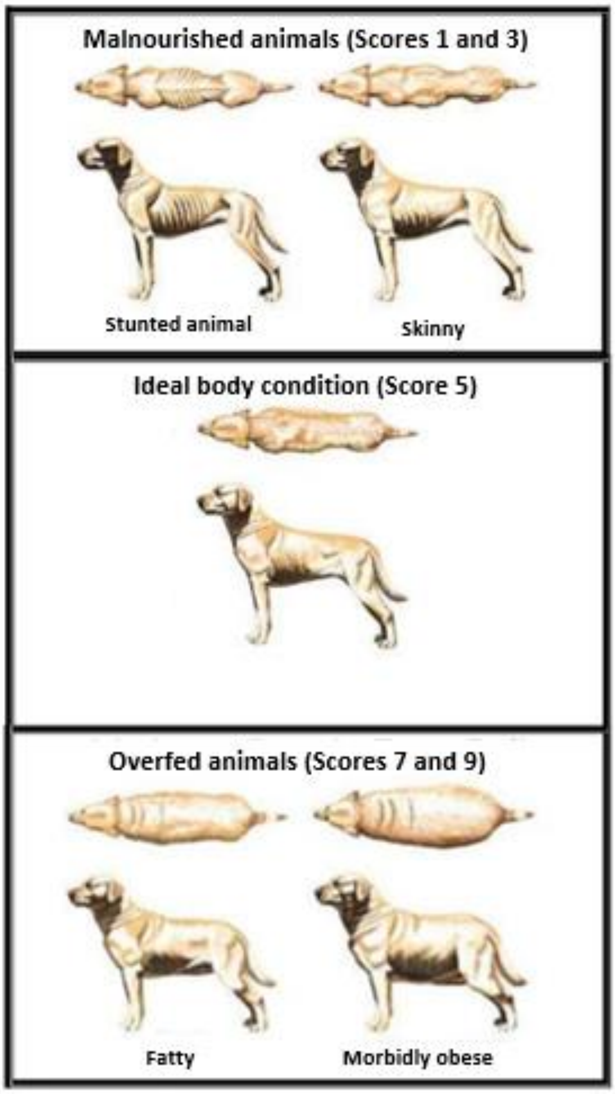

Figure 1. Representation of different body scores in dogs. Source: Adapted of Rodrigues (2011).

3.2.3 Physiological parameters

- Blood pressure

To evaluate systolic, diastolic and median arterial pressure (PAS, PAD and PAM, respectively), the non-invasive oscillometry method was used, with a portable blood pressure device HDO. The cuff has been adapted to the base of the tail or the left forelimb, proximal to the humerus-radio-ulnar joint (Figure 2), recorded in mmHg.

Figure 2. Measurement of arterial pressure in an obese bitch (A) at Veterinary Hospital Prof. Dr. Ivon Macêdo Tabosa, Federal University of Campina Grande (HVUIMT/UFCG), Campus of Patos, Paraíba, using a portable non-invasive oscillometry pressure device HDO (B). Source: HVUIMT/UFCG; 2019.

a) Electrocardiographic variables:

The electrocardiographic variables were obtained using the computerized electrocardiograph (InCardio Duo 2.2.5), the heart rate, duration and amplitude of the P wave being recorded in milliseconds (ms) and millivolts (mV), respectively, duration of the complex QRS (in milliseconds), wave amplitude R (in millivolts), wave amplitude S (in millivolts), duration and amplitude of wave T in milliseconds and millivolts, respectively, duration and unevenness of segment ST, respectively in milliseconds and millivolts, and the intervals of waves P and R (PR), in milliseconds, and of waves Q and T (QT) in milliseconds. The parameters were obtained with the animal in right lateral decubitus, being the reading of the parameters carried out in derivation II (Figure 3).

Figure 3. Electrocardiographic evaluation of a non-obese bitch at Veterinary Hospital Prof. Dr. Ivon Macêdo Tabosa, Federal Univerity of Campina Grande (HVUIMT/UFCG), Campus of Patos, Paraíba. Source: HVUIMT/UFCG; 2019.

3.2.4 Laboratory parameters

A sample of 3 mL of venous blood from the cephalic vein was collected by puncture, divided into two aliquots, and placed in tubes with and without anticoagulant (EDTA). Next, the collected material at Medical Clinic of Small Animal sat HVUIMT/UFCG was identified and sent to the Lab of Clinic Pathology at the same institution. The animals were examined at Veterinary Center PetBem.

After the same collecting procedure, samples were sent to Animal Vetlab for the determination of values of the erythrogram (Red Cells- He, Hemoglobin - Hg, Hematocrit - Ht, Mean Body Volume - VCM, Mean Corpuscular Hemoglobin - HCM, Mean Corpuscular Hemoglobin Concentration - CHCM, and Range of Red Blood Cell Distribution - RDWC), platelet count, leukogram (Total Leukocytes - Leuk., Segmented - Seg., Lymphocytes- Lymph., Monocytes - Mon., Eosinophils - Eos., Basophils - Bas.), hepatic enzymes (alanine aminotransferase - ALT and alkaline phosphatase - FAL), kidney enzymes (urea - URE and creatinine - CRE), total proteins (PT) and albumin (ALB).

For comparative evaluation and standardization of the results, the obtained values were organized into canine species and age group from one to eight years, based on the reference values described in the literature (KANEKO, 1997; MEYER; HARVEY, 2004; WEISS; WARDROP, 2010).

3.2.5 Obesity and disease relationship

After a definitive diagnosis given by the Veterinarian, the tutor's main complaint and the values of the laboratory tests were gathered and correlated with the animals' body condition score and fat percentage.

3.3 Statistical analysis

Data related to risk factors were analyzed descriptively. The numerical values obtained from the physiological and laboratory parameters were submitted to analysis of variance (ANOVA), followed by Tukey's test ($P<0.05$), using the statistical program GraphPad Instat®, considering a significance level of 5% ($P<0.05$).

4 Results and Discussion

Of the animals studied in the Control Group, five were non-neutered males (34%) and 10 females (66%), five being neutered (33%) and five non-neutered (33%). In the Obese Group, four were neutered males (25%) and 11 females (75%), seven being neutered (44%) and four intact (31%). Such information corroborates the studies of Diez and Nguyen (2006), and Oliveira and Zimmermann (2016), in which there is a prevalence of illnesses in neutered females When compared to males. In the Control Group, nine had no indication of race SRD (60%), two belonged to the race Pinscher (13.33%), one to Labrador (6.67%), one to Yorkshire Terrier (6.67%), one to Pit Monster (6.67%), and one to Poodle (6.67%). In the Obese Group, seven animals, were SRD (46.66%), two of race Beagle (13.34%), two were German Spitz (13.34%), two Poodle (13.34%), one Shih-Tzu (6.66%), and one Labrador (6.66%). Silva et al. (2017) stated that the races with smallest predisposition for developing illnesses are Golden Retriver, Labrador, Cocker Spaniel, Dachsund and Beagle. However, studies conducted by Jericó and Scheffer (2002) indicate that the races most predisposed to illness are SRD, Cocker Spaniel and Poodle. Aptekmann et al. (2014) found that 15% of dogs belonging to race Poodle, 8% to English Cocker Spaniel, 8% to American Pit Bull Terrier, 7% to Labrador Retriever, 5% to Teckel, 4% to Rottweiler, 4% to Boxer, 3% Schnauzer, 3% to Beagle, and 15% to the remaining races, were affected by illnesses.

In the Control Group, six animals were considered of small-medium size (40%), four as medium size (26.66%), three as of small size (20%), one as a miniature (6.67%), and one as large-sized (6.67%). Among individuals in the Obese Group, five were considered as of small size (33.34%), five as of medium size (33.34%), two as miniatures (13.33%), two as medium-sized (13.33%) and one as large sized (6.66%). Corroborating the data of this study, Seok (2011) pointed out that dogs of small races have a larger probability of developing obesity, when compared with races of larger sizes. This situation was also observed by Diez and Nguyen (2006).

The incidence of obesity increases as the animal becomes older, being diagnosed within an age group that varies between five and eight years of age (BYERS et al., 2011; ALCÂNTARA, 2014). Carciofi (2005) pointed out that the age group with the largest predisposition to obesity is found between 5 and 10 years of age. For percentage of corporeal fat in the Control Group, the median age was 6.2 ± 2.7 years and for the Obese Group, 7.3 ± 1.8 years. Complementarily, the Control Group obtained an average weight of 13.8 ± 9.4 kg, while the Obese Group obtained 19.5 ± 11.6 kg. In a similar study using 80 obese dogs, Carvalho (2015) observed that the mean weight of these animals was 13.76 kg. This mean may vary, however, depending on the size of the animals prevailing in the study.

The values of abdominal circumference and percentage of body fat (Table 2) show significant statistical variability at $P>0.05$.

Table 2. Mean Values and Standard Deviation of waist circumference and percentage of body fat in samples of obese and non-obese dogs from samples of obese and non-obese dogs treated at Hospital Veterinário Universitário Prof. Dr. Ivon Macêdo Tabosa and PetBem Veterinary Center, in the city of Patos - PB.

Group	Weight (kg)	AC (cm)	% CG	
			Males	Females
CG	13.8 ± 9.4	63 ± 20	18.7 ± 2.2 a	22 ± 3 a
OG	19.5 ± 11.6	65 ± 16.8	40.4 ± 5 b	45 ± 4.7 b

CG: Control Group; OG: Obese Group; AC: Abdominal Circumference; % CG: percentage of body fat in Control Group. The means for a same characteristic, followed by distinct small letters, indicate that values have significant statistical variations, by the Tukey test ($p<0.05$).

The abdominal circumference measured 63 ± 20 cm for the Control Group and 65 ± 16,8 cm for the Obese Group; the percentage of fat was 18.7 ± 2.2% and 22 ± 3 % in the Control Group for males and females, respectively. Laflamme (2006) stated that the percentage of body fat in animals of ECC 5, that is, with a score of members belonging to the Control Group, must be 17% in males and 20% in females.

On the other hand, Burkholder and Toll (2000) considered that animals with 16% to 25% of body fat are normal, without distinction of sex. Thus, members of the Control Group, both males and females, have body fat that is within normality.

In the Obese Group, weights of 40.4 ± 5% for males and 45% ± 4.7% for females were observed. In addition to the percentage margin described by Burkholder and Toll (2000), Laflamme (2006) pointed out that when the percentage of fat is applied to animals of ECC 9 - score of the Obese Grp members -, it must be between 35% in males and 43% in females. Such data indicate that all animals of both sexes were above the ideal weight.

Most animals from the Control Group fed on rations and homemade food, followed by rations exclusively, and fruit (apple, pear and peach) associated with industrialized snack sachets.

Aptekmann et al. (2014) conducted a similar study, in which it was observed that 94% of tutors furnished dry rations, another 35% offered homemade food to their animals, while 48% of tutors offered snacks freely every day to their pets. The food offered to the Control group of animals varied from daily to several times a day, this latter in fact predominating.

In the Obese Group, food was offered freely, in equal quantities during the day, too once a day. Aptekmann et al. (2014) noted that 58% of the dogs were fed twice a day, 8% once a day, and 3% more than three times a day.

On the other hand, in the experiment of Alcântara (2014), obese animals were mostly fed with moist and homemade food, furnished in equal portions along the day; ad libitum feeding was not a predisposing factor for obesity in these animals. Data relative to food management, physical activities and place of resting are presented in Table 3.

Table 3. Factors of risk of obesity associated to food management, practices of physical activities, and place of resting of animals of Control Group (CG) and Obese Group (OG) treated at Hospital Veterinário Universitário Prof. Dr. Ivon Macêdo Tabosa and Petbem Veterinary Center, in the city of Patos-PB.

Risk factors	Category	Absolute Total		Relative Total (%)	
		CG	OG	CG	OG
Feeding	Only ration	10	5	66.6	33.3
	Ration and homemade food	4	9	26.6	60
	Fruits and sachets	1	1	6.8	6.7
Feeding frequency	*Ad libitum*	12	8	80	53.3
	Once a day	3	2	20	13.3
	Regularly		5		33.3
Physical activity	Daily	11	3	73.3	20
	Sporadically	4	3	26.7	20
	No activities		9		60
Resting place	Backyard	12	12	80	80
	Apartment	3	3	20	20

Most non-obese animals had daily physical activities, in contrast to obese dogs, of which nine did not have physical activities (60%). The remaining dogs were divided into equal portions with daily physical activities and sporadic physical activities. In a study made in Australia, dogs with an ideal ECC practiced physical activities regularly, while sedentary animals were, minimally, overweight (Bland et al., 2010).

Mao et al. (2013) indicated that dogs with little or no physical activity were more propense to obesity (51,3%) when compared to animals with a routine of physical exercise (43,1%). On the other hand, Courcier et al. (2010) did not find a correlation between body weight and physical activity.

In both groups, 12 animals (80%) remained most of the time in the backyard, followed by animals living in apartments, a total of three dogs (20%). Animals living in apartments or indoors have higher chances of developing obesity than animals living freely outdoors (ALCÂNTARA, 2014).

When relating the environment in which the animal lives, Colliard et al. (2006) found that 62.3% of obese animals lived in apartments, 37,7% in houses, of which 42,7% had access to the garden, while 28,2% had restricted or prohibited access to outside environments. In regard to resting place, the data diverge from the present study, as similar numbers of animals were found for the conditions of Control and Obese Groups.

Data on endocrine disorders relating to tutor and animal scores of the Control and Obese Groups are presented in Table 4.

Table 4. Risk factors for obesity associated with endocrine, pharmacological and family history, as well as the opinion of the tutors of the animals in the Control Group and Obese Group treated at the Hospital Veterinário Universitário Prof. Dr. Ivon Macêdo Tabosa and PetBem Veterinary Center, in the City of Patos - PB.

Risk factors	Category	Absolute Total		Relative Total (%)	
		GC	GO	GC	GO
History of endocrinopathy	Yes	14	1	93.3	6.7
	No		9		60
	Tutor is unable to inform	1	5	6.7	33.3
Use of corticosteroids	Yes		5		33.3
	No	15	10	100	66.7
	Tutor is unable to inform				
Family history	Yes	1	7	6.6	46.7
	No	14	1	93.4	6.6
	Tutor Is unable to inform		7		46.7
Opinion of the author	Thin	8	2	53.3	13.3
	Ideal weight	7	4	46.7	26.7
	Above weight		8		53.3
	Obese		1		6.7

Of the dogs in the Control Group, 14 had a history of a previously diagnosed and controlled endocrine disease (93.3%) and for there was no recent use of corticosteroids, unlike in the Obese Group, where there was only one (6.7%) endocrinopathy animal; however, five had recently used corticosteroids (33.3%). Catharine, Scott and Yoran (2004) observed the occurrence of obesity in 41% of animals with hypothyroidism. Complementarily, Araujo et al. (2018) relate hypothyroidism in an obese bitch having low response to health treatments to lose weight. Furthermore, Barbosa et al. (2016) state that the most classic symptom of hyperadrenocorticism is a pendular abdomen, a possible result of obesity having been installed.

Eight tutors reported that animals included in the Control Group (53.3%) were thin, while the remaining animals (46.7%), were reported as of ideal weight. Backus and Wara (2016) find that the pet aesthetic culture by men is worrying, since it is believed that excess weight is directly related to health; this concern is exacerbated by the fact that tutors always see their pet's weight as being ideal, even if the individual is often overweight or obese (GOUVÊA et al., 2018). Such a statement can be observed in the Obese Group, where most tutors admitted that the animal was overweight, followed, respectively, by those who believed it was at the ideal weight, thin, and only one, obese (6.7%). Only one animal in the Control Group had a family history of obesity, while in the Obese Group, there were seven animals with such a history (46.7%). Perlstein and Bissada (1977) made one of the first reports on obesity related to other complications, after carrying out a study in Zucher rats that suffered from hereditary obesity. In humans, the heritability coefficient usually exceeds 0.5, which means that it is a trait with a high capacity for transmission to the next generations. (HONRADO, 2018). The mean erythrogram data are represented in Table 5.

Table 5. Mean and Standard Deviation of the erythrogram and number of platelets of the animals in the Control and Obese Groups, treated at the Hospital Veterinário Universitário Prof. Dr. Ivon Macêdo Tabosa and PetBem Veterinary Center, in the City of Patos - PB.

Erythrogram	Groups		Reference values* (1 to 8 years)
	GC	GO	
He (x10^6/µL)	6.67 ± 1.24 a	6.32 ± 1.16 a	5.5 – 8.5
Hg (g/dL)	13.54 ± 2.1 a	13.11 ± 2.45 a	12 – 18
Ht (%)	39.73 ± 6.9 a	39.66 ± 6.5 a	37 – 55
MCV (fl)	61.3 ± 6 a	61.3 ± 7.2 a	60 – 77
MCH (pg)	21.1 ± 2.5 a	19.1 ± 4.5 a	19.5 – 24.5
CHCM (g/dL)	32.97 ± 3.1 a	32.88 ± 2.4 a	32 – 36
RDRBC (%)	12.83 ± 1.08 a	12.83 ± 1.3 a	12 – 15
Plaq. (/mm³)	284866 ± 121142.7 a	267106 ± 149634.02 a	200000 – 500000

He: Red Cells; Hg: hemoglobin; Ht: hematocrit; MCV: mean corpuscular volume; MCH: mean corpuscular hemoglobin; CHCM: mean corpuscular hemoglobin concentration; RDRB: range of distribution of red blood cells; Plaq.: plaquetogram. The means of the same characteristic, followed by the same lowercase letter in the columns indicates that the values do not have significant statistical variation, by the Tukey test ($p<0,05$). Source: *Weiss and Wardrop (2010).

The mean and standard deviation of the erythrogram, referring to red blood cells (He), hemoglobin (Hg), hematocrit (Ht), and hematimetric indices: mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (CHCM) and range of distribution of red blood cells (RDRBC), as well as platelet count (Plaq.), did not show a statistically significant difference between the groups.

As proposed in the literature by Weiss and Wardrop (2010), the mean hematological values referring to the erythrogram and platelet count were within the reference values for the selected species and age groups. An experiment performed by Harishankar et al. (2011) with obese rats showed that obesity did not confer significant changes in the erythrogram of the animals, with the exception of thrombocytopenia, which was not observed in this study.

Martins et al. (2012) found in their experiment that the averages observed for erythrogram and platelet count in obese dogs were within the normal range, with the exception of the low concentration of RDRBC, which was also not observed in the present study.

The leukogram (Table 6), evaluated from total leukocytes (Leuk.), segmented elements (Seg.), lymphocytes (Lymph.), monocytes (Mon.), eosinophils (Eos.) and basophils (Bas.), showed no significant variation between groups. According to the literature proposed by Kaneko (1977) and Weiss and Wardrop (2010), the mean values were not out of the standard for the species evaluated, with the exception of the ALB and ALP tests for the animals of the Obese Group, which were increased.

Table 6. Mean and Standard Deviation of leukograms of obese and non-obese animals treated at Hospital Veterinário Universitário Prof. Dr. Ivon Macêdo Tabosa and PetBem Veterinary Center, in the City of Patos - PB.

Leucogram	Groups		Reference values* (1 to 8 years)
	CG	OG	
Leuk. (mm³)	11698 ± 6728.3 a	13315 ± 7919.3 a	6000 - 17000
Seg. (mm³)	8637 ± 4734.25 a	11580 ± 4734.4 a	3000 - 11500
Lymph. (mm³)	3409 ± 2587.2 a	3160 ± 1725.06 a	1000 - 4800
Mon. (mm³)	619 ± 616.2 a	829 ± 693.21 a	150 - 1350
Eos. (mm³)	760 ± 1128.03 a	643 ± 1075 a	100 - 1250
Bas. (mm³)	12,6 ± 33.4 a	0 ± 1 a	0 - 1

Leuk.: total Leukocytes; Seg.: Segmented Elements; Lymph.: Lymphocytes; Mon.: Monocytes; Eos.: Eosinophils; Bas.: Basophils; CG: Control Group; GO: Obese Group. The means of the same characteristic, followed by the same lowercase letter in the columns, indicate that the values do not have a statistically significant variation, according to the Tukey test ($p<0.05$). *Source: Meyer and Harvey (2004).

According to what was described by Meyer and Harvey (2004), all parameters remained within the physiological limits, with the exception of the Segmented Elements for the Obese Group and Basophils for the Control Group, where both cell groups presented mean values above the confronted values in the literature for canine species. However, according to Martins et al. (2012), the animals in their study showed only an increase in Serum Rods, with the other parameters remaining within the normal range. On the other hand, Roncoski et al. (2014) described in their work carried out with 12 obese dogs an increase in the numbers of Neutrophils in 8% of the animals, and Monocytopenia in 8%, with the remaining values unchanged.

The increase in segmented cells, according to Laurino (2009), is commonly observed as a result of situations of chronic stress, caused by factors such as diseases, confinement and social isolation.

In research by Anjos et al. (2012), involving a hematological evaluation of dogs with hemoparasitosis, an increase in Basophils was observed in about 10% of the total number of animals, which were infected. Approximately 13% of the dogs were infected with Anaplasma platys. The presence of these hemoparasites was indeed observed in animals from both groups in the present study.

Studies carried out by Vendramini (2019) involved hematological evaluation of obese and non-obese dogs. It was possible to observe that there were no relevant data about the increase of segmented leukocytes and basophils in dogs in both classifications. It was observed that the values remained within the ideal, or below, for the species.

The values of serum biochemical tests, Alanine Aminotransferase (AAT), Albumin (ALB), Alkaline Phosphatase (ALP), Total Proteins (TP), Urea (URE) and Creatinine (CRE) (Table 7), also showed no significant variations between groups (Table 7). According to the literature proposed by Kaneko (1977) and Weiss and Wardrop (2010), the mean values did not differ significantly from the standard for the species evaluated. Only ALB and ALP tests for animals of the obese group were increased.

Table 7. Mean and Standard Deviation of the biochemical tests of samples obtained from obese and non-obese animals treated at the University Veterinary Hospital Prof. Dr. Ivon Macêdo Tabosa and PetBem Veterinary Center, in the City of Patos - PB.

Exam	Group		Reference values*
	CG	OG	
AAT (U/L)	25.75 ± 12.84 a	28.25 ± 21.56 a	21 - 102
ALB (g/dL)	3 ± 1 a	4 ± 1.31 a	2.6 - 3.3
ALP (U/L)	48.8 ± 0 a	522.8 ± 470 a	20 -156
TP (/ dL)	6.6 ± 0 a	3 ± 0 a	5.4 - 7.1
URE (mg/dL)	39.15 ± 10 a	34.7 ± 2.44 a	21.4 - 59.92
CRE (mg/dL)	0.625 ± 0.36 a	0.7 ± 0.35 a	0.5 - 1.5

AAT: alanine aminotransferase; ALB: albumin; ALP: alkaline phosphatase; TP total proteins; URE: urea; CRE: creatinine; CG: Control group; OG: Obese Group. The means of the same characteristic, followed by the same lowercase letter in the columns, indicates that the values do not have a statistically significant variation, according to the Tukey test ($p<0.05$). *Source: Kaneko (1997); Weiss and Wardrop (2010).

Carneiro (2013) and Rodrigues (2011) pointed out that the increase in blood levels of ALB occurs exclusively in cases of dehydration, which, according to Martins (2012), may be related to the age group of the animals. This is in line with the data collected in this work, since the presence of a certain degree of dehydration is common in older animals.

Another relevant factor is the hydrophobic character of the fat tissue. Therefore, the amount of fat is inversely proportional to the amount of water in the body (NELSON; COX, 2014). However, it is important to emphasize that the lipemic serum can interfere with the reading of some exams (BRUNETTO et al., 2011).

Carneiro (2013) and Lopes, Biondo and Santos (2007) pointed out that the increase in ALP in dogs is indicative of intra- or extra-hepatic cholestasis. This substance, according to Veiga (2005), is common in animals with Diabetes Mellitus. type I. However, the occurrence of the disease was not reported by the tutors in any questionnaire of this study.

The values obtained on the electrocardiogram did not differ statistically between the groups, as can be seen in Table 8.

Table 8. Mean and Standard Deviation of electrocardiographic variables obtained from obese and non-obese dogs treated at the University Veterinary Hospital Prof. Dr. Ivon Macêdo Tabosa and PetBem Veterinary Center, in the City of Patos - PB.

Variable	Group			
	The variables related to systolic (SBP), diastolic (DBP) and mean (MBP) blood pressure, in addition to heart rate (HR), statistically showed no difference (Table 9) for CG		OG	
P (wd)	46.7 ± 6.46 a		46.9 ± 5.49 a	
P (wa)	0.32 ± 0.4 a		0.20 ± 0.07 a	
PR (i)	88 ± 30.6 a		84.92 ± 20.5 a	
QRS (wd)	Small races	Large races	Small races	Large aces
	54.5 ± 8.06 a	56.18 ± 11.43 a	50 ± 13.16 a	50 ± 12.18 a
QT (i)	195,1 ± 25.51 a		194 ± 30.4 a	
T (wd)	61.9 ± 12 a		62.97 ± 16.24 a	
T (wa)	0.048 ± 0.22 a		-0.02 ± 0.23 a	
ST (s)	60.75 ± 23,4 a		70.89 ± 29.24 a	
R (wa)	1.001 ± 0.42 a		0.796 ± 0.46 a	
Q (wa)	-2.42 ± 7.23 a		0.013 ± 0.24 a	
S (wa)	-0.12 ± 0.09 a		-0.04 ± 0.15 a	

P (wd): P wave duration; P (wa): P wave amplitude; PR (i): PR interval; QRS (wd): QRS wave duration; QT (i): QT interval; T (wd): T wave duration; T (wa): T wave amplitude; ST (s): ST segment; R (wa): R wave amplitude; Q (wa): Q wave amplitude; S (wa): S wave amplitude. CG: Control Group; OG: Obese Group. Means followed by the same lowercase letter in the columns indicates that the values do not have statistically significant variation, by Tukey's test ($p<0.05$).

There were no changes for P wave duration and amplitude, PR and QT intervals; both groups maintained low values of amplitude of waves R and S. In addition, they showed a slight increase in the wave duration of the QRS wave duration in small breed dogs belonging to the Control Group (TILLEY, 1992; WOLF; CAMACHO; SOUZA, 2000; CONCEIÇÃO et al., 2005; PELLEGRINO et al., 2010; SANTILLI et al., 2018).

However, the alterations found were minimal and without great importance for the cardiac electrophysiology of these animals. The data disagree with Jericho, Silva and Machado (2006), who verified in their work a prevalence of 72.4% of obese dogs with some alteration in the electrocardiogram.

Complementarily, Ferreira (2007) used 474 dogs in his work. He showed that the most common electrocardiographic alterations were: increased QRS wave duration (24.31%), T wave amplitude, low QRS voltage (8.56%), deviation of the depolarization axis to the left (8.56%), deviation of the electrical axis to the right (6.51%), and P “mitrale” (6.16%).

In the electrocardiogram, sinus rhythm was observed in the Control Group in eight animals (53.33%), and in seven respiratory sinus dysrhythmia (46.67%). In the Obese Group animals, four had sinus rhythm (26.66%), nine had respiratory sinus dysrhythmia (60%), one had sinus tachycardia (6.66%), and one had sinus bradycardia (6.66%).

According to Camacho and Mucha (2014), sinus dysrhythmia is considered physiological in dogs, while sinus bradycardia can be justified by the use of digitalis and hypothyroidism. Sinus tachycardia would be related to arousal (CAMACHO; MUCHA, 2014), according to Camacho and Mucha (2014), a fact evidenced during the examination of the patient under study in the research. The variables related to systolic, diastolic and mean blood pressure, in addition to heart rate, showed no difference statistically (Table 9).

Table 9. Mean and Standard Deviation of Systolic, Mean and Diastolic blood pressures (SBP, MBP and DBP, respectively) and heart rate (HR) obtained from obese (OG) and non-obese (Control Group) animals treated at the University Veterinary Hospital Prof. Dr. Ivon Macêdo Tabosa and PetBem Veterinary Center, in the City of Patos - PB.

Group	SBP (mmHg)	MAP (mmHg)	DBP (mmHg)	FC (bpm)
CG	141 ± 27.72 a	93 ± 11 a	71 ± 17.46 a	112 ± 29.55 a
OG	142 ± 17.23 a	95 ± 11.6 a	84 ± 22 a	114 ± 21.8 a

SBP: Systolic Blood Pressure; MAP: Mean Arterial Pressure; DBP: Diastolic Blood Pressure. The averages of the same characteristic, followed by the same lowercase letter in the columns, indicate that the values do not have statistically significant variation, by the Tukey test ($p<0.05$).

According to the classification proposed by Tilley and Goodwin (2002), both groups showed a slight increase in Systolic Blood Pressure; the animals in the Control Group did not show an increase in Diastolic Blood Pressure, which in turn was observed in the animals in the Obese Group. Carciofi (2005) stated that the correlation between obesity and hypertension is controversial, since the animal may have high blood pressure when compared to a healthy dog, and not necessarily be hypertensive. On the other hand, Santos (2016) stated that obesity is a relevant risk factor for the development of arterial hypertension, in addition to other cardiac alterations. An investigative and follow-up work is necessary, correlating the patient's clinical condition with his cardiovascular parameters.

The Heart Rate remained within the normal range. However, the obese animals had a higher mean value than in the Control Group animals. This may corroborate the studies on cardiac autonomic neuropathy (KLEIN et al., 2004; MARCHI et al., 2016).

Regarding the tutor's main complaint, the data are presented in Table 10. It was observed that most of the animals belonging to the Control Group were taken only for routine examinations, followed by some skin lesion, swelling in thoracic limb, apathy and vomiting, cough and halitosis.

Regarding the animals in the Obese Group, there were complaints of cough, halitosis, routine evaluation, apathy and vomiting, fetid odor coming from the ear, difficulty in locomotion and swelling in the face and neck region. Such information proves studies that point out the visual misrepresentation of the tutor in relation to the body score of his animal, since no tutor took his pet to the vet with a complaint of weight gain, or aiming to investigate this problem.

Table 10. Main complaint of animals in the Obese Group (OG) and non-obese group (CG), treated at the Hospital Veterinário Universitário Prof. Dr. Ivon Macêdo Tabosa and PetBem Veterinary Center, in the City of Patos - PB.

Group	Main complaint	Absolute Total	Relative Total (%)
CG	Routine exams	7	46.7
	Skin lesions	2	13.3
	Increase in volume in thoracic limb.	2	13.3
	apathy and vomiting	2	13.3
	Coughing	1	6.7
	Halitosis	1	6.7
OG	Coughing	4	26.7
	Halitosis	2	13.3
	Routine exams	2	13.3
	Apathy and vomiting	2	13.3
	Fetid odor in ear	1	6.7
	Mobility difficulties	1	6.7
	Volume increase in face	1	6.7
	Volume increase in neck	1	6.7

The animals' definitive diagnoses are shown in Table 11.

Table 11. Final diagnosis of the animals in the Obese Group (GO) and non-obese group (CG), treated at the Hospital Veterinário Universitário Prof. Dr. Ivon Macêdo Tabosa and PetBem Veterinary Center, in the City of Patos - PB.

Group	Diagnosis	Absolute total	Relative total (%)
CG	Disease free	6	40
	Hemoparasitosis	3	20
	Neoplasm	2	13.3
	Trauma	1	6.7
	Tracheal collapse	1	6.7
	Tartarus	1	6.7
	Dermatopathy	1	6.7
OG	Hemoparasitosis	2	13.33
	Tracheal collapse	2	13.33
	Tartarus	2	13,33
	Hip dysplasia	2	13.33
	Bronchopneumonia	2	13.33
	Neoplasm	2	13.33
	Trauma	1	6.7
	Disease free	1	6.7
	Dermatopathy	1	6.7

Of the animals belonging to the first group, six were not sick (40%), while only one animal in the second group had the same condition (6.7%), being taken to the veterinarian for routine examinations. In addition, both groups had hemoparasitosis, three in the Control Group (20%) and two in the Obese Group (13.33%). There was no correlation between obesity and hemoparasitosis in the study by Scherer and Mergener (2014), by Canuto, Matias and Aquino-Cortez (2016), or by Guimarães (2019). These studies demonstrated only that the occurrence of hemoparasites is related to the presence of hematophagous vectors, such as fleas and ticks.

In both groups there was a prevalence of one animal diagnosed with some trauma (6.7%). Santoro and Arias (2018) stated that diseases of the central nervous system, especially those related to trauma, confer more complications in large and obese dogs, due to the difficulty in managing the patient's position. In addition, two obese animals were diagnosed with hip dysplasia (13.33%), a condition that was not observed in the other group. A study with two groups composed of obese dogs and with food restriction showed that at two years of age, 67% of obese dogs had hip dysplasia, and only 29% of animals with restricted food developed the disease (LAWLER, 2002).

According to Carciofi (2005), obesity is one of the main risk factors for the development of orthopedic disorders in adult dogs. Yet, it was not a relevant risk factor in this study, since there was no significant number of animals with any changes in the locomotor system.

Two animals were diagnosed with tracheal collapse in the Obese Group (13.33%) and one in the Control Group (6.7%). Obesity is a risk factor for triggering the development of tracheal collapse in dogs, which is in agreement with Carciofi (2005). In addition, two dogs from the obese group had bronchopneumonia (13.33%), which was absent in the animals from the control group. Studies by Debastiani (2018) showed a positive correlation between respiratory problems and obesity. Complementarily, Melo et al. (2014) stated that, in humans, structural changes in the thoracoabdominal region related to excess fat reduce diaphragmatic mobility and rib movement.

In the control group, one animal had tartar (6.7%), an alteration also observed in two animals in the obese group (13.33%). According to Keller et al. (2015) and Khosravi et al. (2013), the relationship between obesity and periodontal diseases in dogs is not established so far. However, in humans, it is known that excess weight is a risk factor for the development of this condition. Debastiani (2018) found that tartar is one of the complications triggered by installed obesity.

The presence of some skin disease was observed in one animal in both groups (6.7%). German (2006) and Silva (2018) stated that the most common skin diseases in obese dogs are seborrhea and pyoderma.

In both groups, two animals were diagnosed with a neoplasm (13.33%). Silva et al. (2017) observed a higher incidence of tumors in obese animals, when compared to non-obese animals. This was not observed in this study, since the groups had an equal number of animals with some kind of tumor.

5 Conclusions

We conclude that obesity in dogs determines important clinical alterations that affect the quality of life of the animals. Overweight can be avoided by employing proper management of diet and providing physical exercises for dogs. The specific correlation between obesity and the diseases found may be more strongly related to the factor responsible for the triggering of each disease. This correlation may be different in both groups. It is necessary to carry out additional tests, in order to detect and treat the possible primary cause of the disease.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

DBS established researched procedures and contributed to the writing of the manuscript, with experience in the theme and specialized pedagogical training, helped to establish the methodology and contributed with the writing of the article, including a revision of the data. MLC contributed with a revision of the final manuscript, including its version into English. APS supervised and was the mentor of this research.

DECLARATION OF INTEREST

The authors declare that they are not subject to any type of conflict of interest with the participants or with any other collaborator, directly or indirectly.

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