Indian J Anim Health (2023), 62(1): 95-106
DOI: https://doi.org/10.36062/ijah.2023.07722

Research Article

Effect of obesity on electrocardiographic and clinical parameters in dogs

Y. K. Meena[1*], S. Gupta[2], R. Tiwari[1], S. Pannu[3] and H. Sharma[1]

[1]Department of Veterinary Medicine, Post Graduate Institute of Veterinary Education and Research, Rajasthan University of Veterinary and Animal Sciences, Jaipur- 302 031, Rajasthan, India; [2]Veterinary Clinical Medicine, Rajasthan University of Veterinary and Animal Sciences, Bikaner- 334 001, Rajasthan, India; [3]Animal Reproduction, Gynaecology and Obstetrics, ICAR National Dairy Research Institute, Karnal- 132 001, Haryana, India

Abstract

The present study was carried out to evaluate electrocardiographic and clinical parameters change in obese dogs. In the current study, 210 adult dogs of any age, gender, or breed were screened for obesity. Eighteen obese dogs were undertaken for clinical examination and haematological parameters estimation for the present study. Six dogs that appeared to be in good health but were omitted from the study due to selection criteria served as controls. In the present study, the mean rectal temperature of obese dogs was significantly ($p<0.05$) lower than apparently healthy dogs, while pulse rate, heart rate and respiratory rate were significantly higher ($p<0.01$) as compared to the mean value of apparently healthy dogs. The mean values of systolic, diastolic and mean arterial blood pressure were significantly ($p<0.01$) high in obesity group dogs as compared with corresponding mean values of apparently healthy group dogs. The ECG of obese dogs revealed no significant difference in values of P-amplitude, P-duration, PR-interval, QRS-interval, R-amplitude and QT-interval values as compared to healthy dogs.

Keywords: Blood pressure, Body condition score, Dog obesity, Electrocardiography

Highlights

- Dog obesity is a common condition in small animal veterinary practice associated with the risk of developing pathologies that reduce the quality of life and longevity.
- Canine obesity also alters cardiac functions; it changes cardiac rhythm, left ventricular hypertrophy, increased blood pressure and plasma volume.
- Obese dogs are highly susceptible to developed orthopaedics diseases, diabetes mellitus, changes in lipid profiles, cardio-respiratory diseases, urinary disorders, reproductive disorders, and dermatological diseases.
- Canine obesity is also associated with endocrinological diseases, including hypothyroidism, hyperadrenocorticism, and insulinoma.
- ECG use for diagnosed respiratory sinus arrhythmia (ASR) and sinus tachycardia in obese dogs.

INTRODUCTION

Canine obesity poses a serious threat as it is a growing endemic problem in developing countries. Canine obesity is the greatest clinical challenge for veterinarians, which is increasing with a similar prevalence in human beings (McGreevy *et al.*, 2005; Veiga *et al.*, 2008). Obesity is a situation where a deposit of excessive fat in the body. Obesity is a result of an imbalance between the intake and usage of calories. The body stores these extra calories as fat when the intake is higher. The terms overweight and obese dog are used when they have 15-30% and above 30% weight increases from their ideal body weight, respectively (Simpson *et al.*, 1993; Laflamme, 2001; Ramsey and Holden, 2009). Nine-point body condition score (BCS) system is a validated semi-quantitative diagnostic method of

*Corresponding Author; E-mail: yogendra.meena8@gmail.com

assessing the body condition of a dog which is based on visual assessment and palpation (Laflamme, 1997). Body condition scores involve using visual information on overall body shape and palpation of regions of the body known to accumulate fat in obese dogs (Burkholder and Bauer, 1998). Recent studies reported that 3-40% of dogs were obese worldwide (Robertson, 2003; McGreevy *et al*., 2005; Lund *et al*., 2006; Weeth *et al*., 2007; Courcier *et al*., 2010). Higher occurrence of dog obesity is commonly seen in Labrador Retrievers, Cairn Terriers, Cocker Spaniels, Dachshunds, Basset hounds, Cavalier King Charles Spaniels, Golden Retrievers and Beagles breeds of dogs (Gurpreet, 2019). Obesity appeared to cause exercise intolerance via airway dysfunction in dogs, but this was evident only during hyperpnoea (Bach *et al*. 2007; Salome *et al*. 2009). Obesity is strongly associated with fatty liver syndrome, characterized by excessive fat deposition on the liver which causes inflammation and fibrosis. Obesity is also linked with hypertension and left ventricular hypertrophy in dogs (Hall, 2003). In dogs' obesity caused most diversity in electrocardiographic (ECG) abnormalities. Obesity causes respiratory sinus arrhythmia (ASR) and sinus tachycardia. In recent studies, electrographic findings in obese dogs showed enlarged left ventricle and ST segment depression (Raj *et al.* 2016; Palatucci *et al*. 2018). Therefore, it becomes necessary to increase awareness about dog obesity as a serious medical condition in small animal veterinary practices. The present study was planned with the following objectives to record prevalence, risk factors and clinical parameters alteration in dogs suffering from obesity.

MATERIALS AND METHODS

Source of animals

The present study was conducted on dogs presented for routine clinical examination/ vaccination in the canine out door of the Veterinary Clinical Complex, College of Veterinary and Animal Science, Bikaner.

Selection of animals

Two hundred and ten adult dogs of different breeds and both sexes were screened for obesity based on body condition score. The body condition scores of dogs were allotted as per whole number value 1 to 9 during the time of visual examination and palpation system (Laflamme, 1997; Burkholder and Toll, 2000).

According to Ricci *et al*. (2007), BCS dividing into four classes were considered: Lean dogs (BCS 1-3), Ideal body weight dogs (BSC 4-5), Overweight dogs (BCS 6-7) and obese dogs (BCS 8-9).

On the basis of body condition score, a minimum of eighteen obese dogs were divided into three groups having six in each for clinical examination and haemato-biochemical parameters estimation. Six healthy dogs without discrimination of age, sex, breed and based on selection criteria were taken as the control group in the present study.

History

Information regarding breed, age, gender, neutering, type of food, number of feeding per day, physical exercise, and owner's awareness about their pet's obesity were collected as per the designed questionnaire.

Clinical examination

A complete thorough clinical examination of the dogs was done at the beginning of the study. Clinical parameters like rectal temperature (^{o}F), pulse rate (per minute), heart rate (per minute), respiration rate (per minute), blood pressure (mmHg) and electrocardiography changes were recorded. A thorough auscultation of heart and lungs was done. Body Condition Score of each dog was evaluated using 9-points score (Laflamme, 1997) and recorded in the questionnaire.

Auscultation of heart and lungs

Auscultation of cardiac area: Heart was auscultated on the left side at 2nd intercostals space just above sternum, 4-5th intercostals space at costochondral junction, and right side at 3rd-5th intercostals space at costochondral junction.

Thoracic auscultation: This was done using a stethoscope on both sides of lung fields of the thorax. Following parameters were examined.

A. Normal lung sounds (bronchial and vesicular)
B. Type and location of any abnormality in lung sounds (Crackles and wheezes)
C. Determining the specific phase of the respiratory cycle in which abnormality in lung sounds occur, which was important for categorizing the sound and determining the most likely pathology.

Electrocardiography

Electrocardiographic recording of all obese dogs was done at the time of complete clinical examinations. The following parameters were studied on lead II as per the method described by Martin (2007).

1. P- amplitude,
2. P- duration
3. P-R interval
4. QRS complex interval
5. R- amplitude
6. Q-T interval

The standard electrocardiograph was used for recording the electrocardiogram having the following details.

(i) Electrocardiograph: Electrocardiographic tracing of each obese dog was recorded with a digital electrocardiograph manufactured by Khera Instruments Pvt. Ltd., Delhi. The sensitivity of the machine was adjusted so that for 1 mv current deflection was at 10 mm. The paper speed was set at 25 mm/sec.

(ii) Electrodes: The standard electrocardiographic cable was made of five separate cable electrodes labeled right arm (RA), left arm (LA), right foot (RF), left foot (LF) and the V lead or exploring precordial chest lead. Specific colour cable used to indicate each electrode as follows:

RA- Red, LA- Yellow, RF- Black, LF- Green, V- white

Electrode contact with the animal's body was achieved by connecting alligator clips.

Lead system used:
Bipolar standard lead:
Lead II: Left hind-limb positive
Right fore-limb negative

Procedure for recording the electrocardiogram: The animal was muzzled and placed in right lateral recumbency on the examination table (insulated). An attendant held the fore-limbs of dog with his right hand and the hind-limbs with his left hand. His right forearm rested on the dog's shoulder while the left-fore arm was placed over its hind quarters. Gaps were being made between the fore-limbs and hind-limbs by placing two fingers to avoid direct contact between limbs and electrodes attached to the limbs.

The area just above the elbow in the fore-limb was cleaned with cotton, and ECG electrode gel (Technoking) was liberally applied in sequence to degrease the site and facilitate conduction of electrical charges. On the hind-limbs, the skin just above the stifle was prepared in a similar manner.

Alligator clips were connected to the skin with the appropriate limb electrodes, i.e., LA- left fore-limb, RA- Right fore-limb, LF- left hind-limb, RF- Right hind-limb. Care was taken to restrict the movement of animal. The heat sensitive electrocardiogram paper was inserted into the slot provided. After checking all lead connections, the off/on button in the electrocardiograph was pressed on and P-QRS-T deflections were recorded on the moving electrocardiogram paper.

After the end of recording, the electrocardiogram strip was detached from the roll and identification marks were made on it: case number, date, age, breed and stage of presentation of dogs. After verifying all the lead tracing in the paper, the clips were released from the dog's body.

Blood pressure measurement (mmHg)

Non-invasive blood pressure (systolic and diastolic blood pressure) of all the obese dogs was recorded using a sphygmomanometer

(SunTech Vet) with latex bulb for pumping up the cuff. This technique detects arterial pulsation by using an inflating and deflating cuff wrapped around either antebrachium or distal pelvic limb (Stepien and Rapoport, 1999) in a quiet, comfortable environment after the dog has become acclimated for at least a few minutes. The first reading was discarded, and 3 additional measurements were obtained with submitting 20% variability, averaging to yield the blood pressure measurement (Creedon and Davis, 2012). This method is considered the best method for dogs in clinical use (Sorvoja and Myllyla, 2006).

Mean arterial blood pressure (mmHg): Mean arterial blood pressure was calculated by the following formula:
Mean arterial pressure (MAP) = (Systolic blood pressure + (2×Diastolic blood pressure))/3

Statistical analysis: The data obtained in the present research work was statistically analyzed and compared using standard formulas given for mean, standard error and t-test as per the procedures explained by Snedecor and Cochran (2004).

RESULTS

This study was carried out to record clinical parameters (blood pressure and electrocardiographic) in dogs suffering from obesity. On the basis of BCS, eighteen obese dogs were divided into three groups having six in each for clinical examination, haemato-biochemical parameters estimation and therapeutic trial. Six normal weight dogs without discrimination of age, sex, and breed were included in the control group.

Clinical observations

Temperature, pulse and respiration: The Mean ± SE values of rectal temperature (°F), pulse rate (per minute), heart rate (per minute) and respiration rate (per minute) of obese dogs and apparently healthy dogs are presented in Table 1 and depicted in Fig. 1.

Rectal temperature (ºF): The mean ± SE values of rectal temperature (ºF) in obese dogs and apparently healthy dogs were 101.10±0.31 and 101.96±0.21, respectively. The obese dog's temperature was significantly lower (p<0.05) than healthy dogs.

Pulse rate (per minute): The mean ± SE values of pulse rate (per minute) in obese dogs and apparently healthy dogs were 132.05±2.09 and 97.85±7.99, respectively. In the present study, the mean value of pulse rate in obese dogs was significantly higher (p<0.01) when compared with the mean value of pulse rate of apparently healthy dogs.

Heart rate (per minute): The mean ± SE values of heart rate (per minute) in obese dogs and apparently healthy dogs were 126.72±2.29 and 92.57±7.08, respectively.

Respiration rate (per minute): The mean ± SE

Table 1. Mean ± SE values of temperature (°F), pulse rate (per minute) and respiration rate (per minute) of obese dogs and apparently healthy dogs

Sl. No.	Parameters	Obese dogs (n=18)	Healthy dogs (n=6)	Statistical analysis (T test)
1	Rectal Temperature (ºF)	101.10±0.31	101.96±0.21	S*
2	Pulse rate (per minute)	132.05±2.09	97.85±7.99	S**
3	Heart rate (per minute)	126.72±2.29	92.57±7.08	S**
4	Respiration rate (per minute)	37.83±1.96	27.85±1.70	S**

The asterisk (*) indicates significant (p<0.05) difference, (**) indicates highly significant (p<0.01) difference and NS indicates non significant (p>0.05) difference

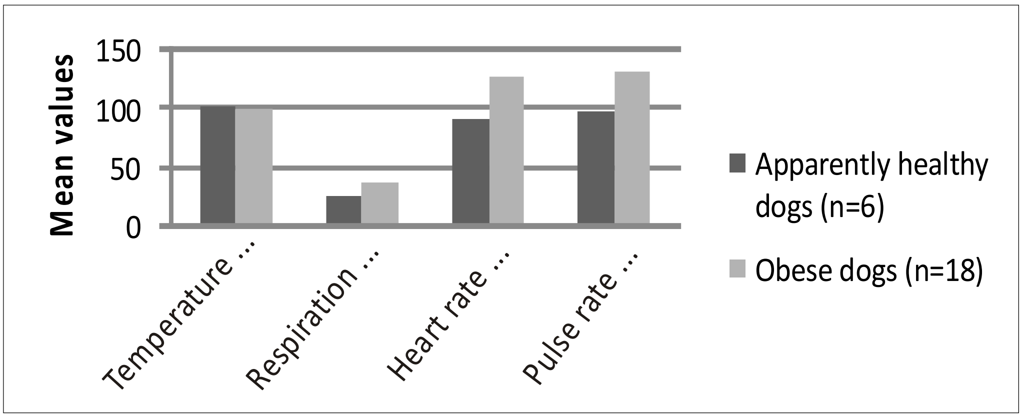

Fig. 1. Mean values of physiological parameters of obese and apparently healthy dogs

values of respiration rate (per minute) in obese dogs and apparently healthy dogs were 37.83±1.96 and 27.85±1.70, respectively. The respiratory rate was significantly higher ($p<0.01$) in obese dogs than apparently healthy dogs.

Blood pressure (mmHg): The Mean ± SE values of systolic blood pressure (mm/Hg), diastolic blood pressure (mm/Hg) and mean arterial blood pressure (mm/Hg) of obese dogs and apparently healthy dogs are presented in Table 2 and depicted in Fig. 2.

The mean ± SE values of systolic blood pressure (mmHg), diastolic blood pressure (mmHg) and mean arterial blood pressure

Table 2. Mean ± SE values of blood pressure (mmHg) of obese dogs and apparently healthy dogs

Sl. No.	Parameters	Obese dogs (n=18)	Healthy dogs (n=6)	Statistical analysis (T test)
1	Systolic blood pressure (mmHg)	162.94±2.75	131.67±4.64	**
2	Diastolic blood pressure (mmHg)	89.05±1.90	81.14±4.15	**
3	Mean arterial blood pressure (mmHg)	113.64±1.87	98.27±4.04	**

The asterisk (*) indicates significant ($p<0.05$) difference, (**) indicates highly significant ($p<0.01$) difference and NS indicates non significant ($p>0.05$) difference

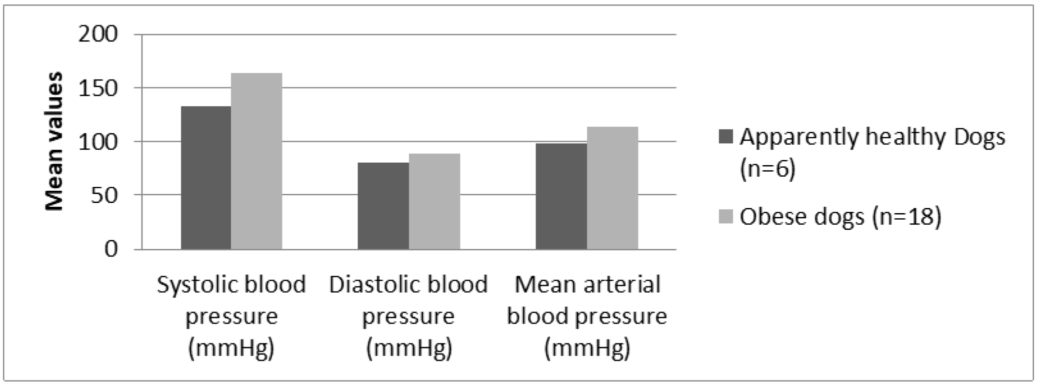

Fig. 2. Mean values of blood pressure (mmHg) of obese and apparently healthy dogs

(mmHg) in obese dogs were 162.94±2.75, 89.05±1.90 and 113.64±1.87, respectively, whereas corresponding value in apparently healthy dogs were 131.67±4.64, 81.14±4.15 and 98.27±4.04, respectively. The mean value of blood pressure was significantly ($p<0.01$) higher in obese dogs than the corresponding mean value of apparently healthy dogs.

Electrocardiogram (ECG): The ECG of obese dogs and apparently healthy dogs were taken on lead II. The mean ± SE values of P-amplitude (mv), P-duration (sec.), P-R interval (sec.), QRS complex interval (sec.), R- amplitude (mv) and Q-T interval (sec.) of obese dogs and apparently healthy dogs are presented in Table 3 and depicted in Fig. 3, 4 and 5.

The mean ± SE value of P-amplitude (mv), P-duration (sec.), P-R interval (sec.), QRS complex interval (sec.), R-amplitude (mv) and R-amplitude (mv) in obese dogs were 0.4±0.02, 0.05±0.002, 0.09±0.002, 0.06±0.004, 1.85±0.05 and 0.26±0.009, respectively, whereas, corresponding values in apparently healthy dogs were 0.4±0.06, 0.04±0.003, 0.08±0.004, 0.06±0.004, 1.65±0.10 and 0.24±0.019, respectively.

Table 3. Mean ± SE values of electrocardiographic variables of obese dogs and apparently healthy dogs

Sl. No.	Parameters	Obese dogs (n=18)	Healthy dogs (n=6)	Statistical analysis (T test)
1	P- amplitude (mv)	0.4±0.02	0.4±0.06	NS
2	P- duration (sec.)	0.05±0.002	0.04±0.003	NS
3.	P-R interval (sec.)	0.09±0.002	0.08±0.004	NS
4	QRS complex interval (sec.)	0.06±0.004	0.06±0.004	NS
5	R- amplitude (mv)	1.85±0.05	1.65±0.10	NS
6	Q-T interval (sec.)	0.26±0.009	0.24±0.019	NS

The asterisk (*) indicates significant ($p<0.05$) difference, (**) indicates highly significant ($p<0.01$) difference and NS indicates non significant ($p>0.05$) difference

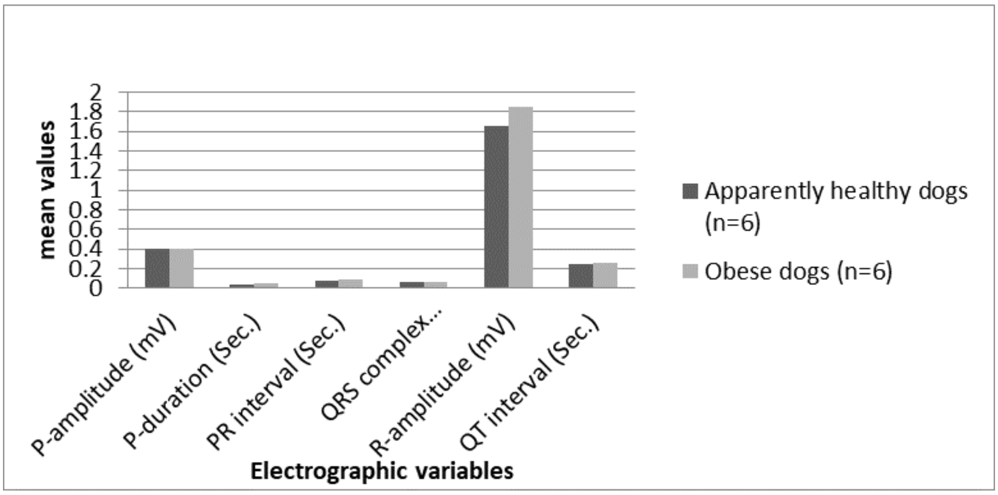

Fig. 3. Mean values of electrocardiographic variables of obese and apparently healthy dogs

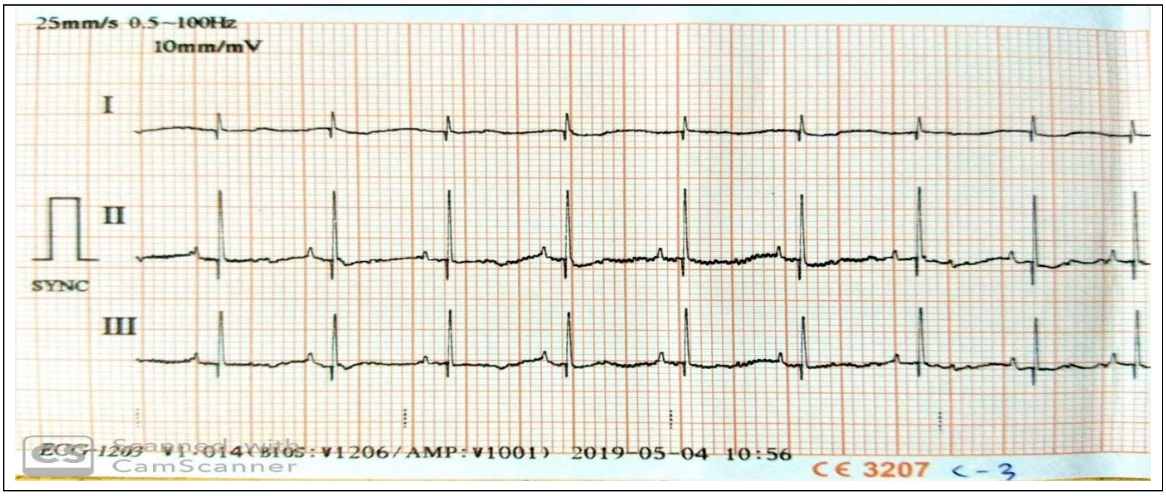

Fig. 4. Electrocardiograph of apparently healthy dog

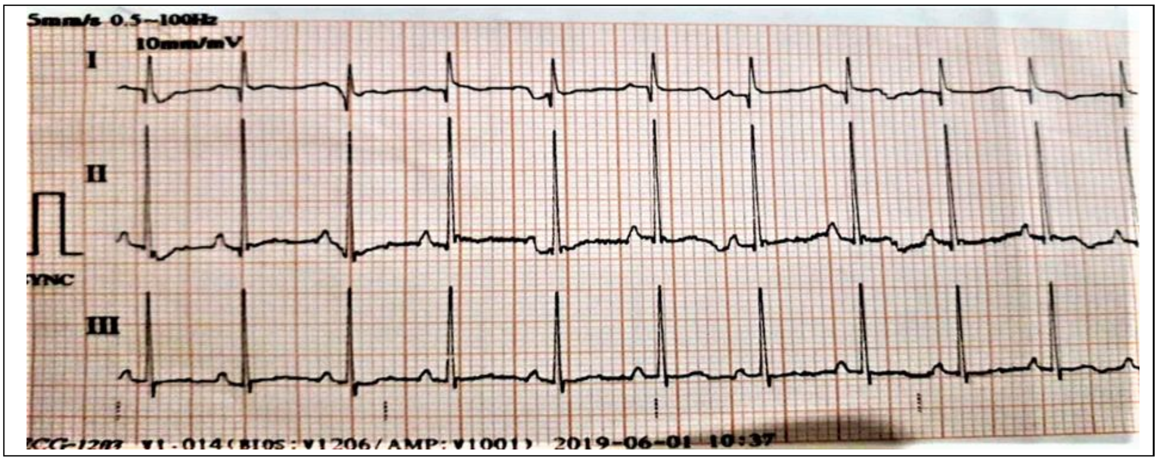

Fig. 5. Electrocardiograph of obese dog showing normal parameters

Fig. 6. Obese dog with recording ECG

Table 4. Ideal body weight of dogs of different breeds (Case *et al.*, 2011)

Sl. No.	Breeds	Body weight (kg) Male	Female
1	Akita	31.0-38.5	30.0-34.0
2	Basset Hound	29.5-34.0	22.5-29.5
3	Beagle	5.8-8.0	5.8-7.0
4	Boxer	25.0-31.0	30.0-31.0
5	Bull Dog	20.0-25.0	18.0-22.5
6	Chihuahua	0.9-2.7	0.9-2.5
7	Chow Chow	20.4-22.5	18.0-22.5
8	Cocker Spaniel	11.3-13.5	9.07-11.33
9	Collie	31.0-38.5	30.0-34.0
10	Dachshund	7.25-10.0	7.25-10.0
11	Dalmatian	22.5-31.0	20.5-25.0
12	Doberman Pinscher	29.5-36.0	25.0-32.0
13	German Shepherd	34.0-41.0	29.5-36.0
14	Golden Retriever	29.5-34.0	25-29.5
15	Great Dane	54.5-81.5	45.5-59.0
16	Labrador Retriever	29.5-36.0	25.0-36.0
17	Pomeranian	1.5-3.0	1.5-2.0
18	Poodle	22.5-27.0	20.5-25.0
19	Pug	6.5-8.0	6.5-8.0
20	Rottweiler	36.0-43.0	32.0-38.5
21	Saint Bernard	59.0-82.0	54.5-72.5
22	Siberian Husky	20.05-27.0	16.0-22.5
23	Yorkshire Terrier	1.8-3.0	1.8-2.7

DISCUSSION

Our study investigated the effect of obesity on clinical and electrocardiography parameters in dogs. In the present study, the body temperature of obese dogs was significantly ($p<0.05$) lower than apparently healthy dogs. Similar to this finding, Landsberg *et al.* (2009), Piccione *et al.* (2011) and Hynd *et al.* (2014) also reported significantly lower rectal temperature in obese dogs than that of lean dogs. The lower rectal temperature in the obese dog may result from increased metabolic efficiency achieved by a regulated lowering of the body like other species of homeotherms (Piccione *et al.*, 2011). Obese dogs have a thicker layer of subcutaneous fat, which alters the thermoregulation mechanism of the body. In obese dogs, lower body temperature might be associated with higher body mass index.

In the present study, the mean value of heart rate and pulse rate in obese dogs was significantly higher ($p<0.01$) when compared with the mean value of pulse rate of apparently healthy dogs. Our finding is in agreement with the findings of Rocchini *et al.* (1989), Granger *et al.* (1994), Van Vliet *et al.* (1995), Truett *et al.* (1998), Verwaerde *et al.* (1999), Kuruvilla and Frankel (2003), Lohmeier *et al.* (2012), Tvarijonaviciute *et al.* (2012) and Pérez-Sánchez *et al.* (2015), who also reported that obesity increases the heart rate, blood pressure (hypertension) in pet animals. Biphasic changes in autonomic nervous system (Increased sympathetic activation and/or reduced parasympathetic control) may be responsible for increased heart rate and blood pressure in obesity (Palatini, 2011). The findings in our study are in accordance with

Lohmeier *et al*. (2012), who reported that body weight significantly positively correlation with higher mean arterial pressure and heart rate. Additionally, in obese dogs, left ventricular free wall thickness at end diastole and end systole are found as compared to lean dogs. Due to the increased fat tissue in obese dogs, the mass of tissues that have to be oxygenated by the heart increases, resulting in a significant increase in heart's function by increasing blood volume and pulse volume, which has to be pumped by the heart.

The respiratory rate was significantly higher ($p<0.01$) in the obese group of dogs than the apparently healthy group of dogs. Similar findings were also reported by Bach *et al*. (2007), Braos *et al*. (2009), Manens *et al*. (2012) and Chandler (2016). The possible reason for higher respiratory rate in obese dogs had significantly greater intra-thoracic fat deposition than lean dogs. Excessive intra-thoracic and intra-abdominal fat concentrations cause disturbance in lung expansion and diaphragm contractility, respectively. It would be important to mention that obesity through previous mechanism significantly exacerbates a pre-existing respiratory problem (Fonfara *et al*., 2011).

The mean value of blood pressure was significantly ($p<0.01$) higher in obese dogs as compared with the corresponding mean value of apparently healthy dogs. The present findings corroborated with Massabuau *et al*. (1997), Verwaerde *et al*. (1999), Montoya *et al*. (2006), Neto *et al*. (2010), Lohmeier *et al*. (2012), Mehlman *et al*. (2013) and Jose Lahm Cardoso *et al.* (2016), who also reported higher systolic blood pressure, diastolic blood pressure and mean arterial blood pressure in obese dogs as compared to lean or normal weight dogs. There are various mechanisms by which obesity causes hypertension, and it involves several organic mechanisms such as activation of the renin-angiontensin-aldosterone system (RAAS), increased activity of the sympathetic nervous system (SNS), which have been described in experimental studies with dogs (Joles, 1998; Palatini, 2011; Chandler, 2016).

In obese dogs with increased adipose tissue, plasma concentrations of angiotensinogen tend to be elevated due to adipose-derived angiotensinogen, which subsequently leads to higher amounts of angiotensin-II and increased angiotensin-II causes vasoconstriction of blood vessels and retention of sodium by the kidneys via aldosterone release which increases the blood pressure and eventually results in cardiovascular dysfunction. Lohmeier *et al*. (2012) suggested that another possible reason may be weight increase induces baroreflex activation and renal denervation abolished obesity-induced hypertension in dogs.

Lower circulating adiponectin (particularly adipokine) concentrations in obese dogs might be related to insulin resistance or reduced insulin sensitivity through the action of AMP-activated protein kinase (Hotta *et al*., 2001). As reported in humans (Jung *et al*., 2014), low adiponectin values might be indicative of hypertension in obese dogs (Tvarijonaviciute *et al*., 2012; Adolphe *et al*., 2014).

In the present investigation, there was a non-significant difference in the mean values of all the variables of electrocardiography of obese dogs and apparently healthy dogs. The results of the present study were in accordance with the results of Neto *et al*. (2010) who reported non-significant alterations of all electrocardiographic variables. In the present study, electrocardiography findings the P wave duration (sec.), prolonged Q-T interval (sec.) and P-R interval were non significantly increasing mean value in obese dogs compared to healthy dogs. In obese dogs, longer P wave duration indicates left atrial enlargement due to atrial fibrillation. Raj *et al*. (2016) suggested that electrical alterations in the ECG might be due to alterations in electrical conduction through the atria and left ventricle hypertrophy. These similar findings were also reported by Wolf *et al*. (2000) and Mehlman *et al*. (2013). The P-R interval indicates the severity of obesity (Alpert *et al*., 2001). In the present study, prolonged Q-T interval (sec.) increases the possibility of left ventricular enlargement and ventricular fibrillation. These findings agree with the result of Piantedosi *et al*. (2016), who reported that the values of free wall of the left ventricle and interventricular septal thickness were higher at end-diastole in obese dogs as compared to normal weight dogs.

The present study was conducted to record clinical parameters, blood pressure and electrocardiography in obese dogs. In the present study, there was a significant difference in clinical parameters in obese dogs as compared to apparently healthy dogs. The mean rectal temperature of obese dogs was significantly ($p<0.05$) lower than apparently healthy dogs, while pulse rate, heart rate and respiratory rate were significantly higher ($p<0.01$) as compared to the mean value of apparently healthy dogs. The mean values of systolic blood pressure, diastolic blood pressure and mean arterial blood pressure were significantly ($p<0.01$) higher in obese dogs as compared with corresponding mean values of apparently healthy dogs. The ECG of obese dogs revealed a non-significant difference in values of P-amplitude, P-duration, PR-interval QRS interval, R amplitude and QT interval values compared to healthy dogs. The present study concluded that dog obesity affects the major vital organ function and decreases the life span of companion animals. Canine obesity alters physiological parameters of the body like respiratory rate, heart rate and metabolic rate. It also causes hypertension which is a risk factor for cardiovascular diseases. The present study suggests the owners for regular exercise and monitors the body weight of dogs. Exercise and a low fat-high protein diet are better for managing obesity in dogs.

Conflict of interest: Authors have no conflict of interest in this study.

Author's contribution: YKM: Conducted research, data generation, and preparing original draft; SG: Guided in the study, and conceptualization; RT: Help in sample collection; SPP: Engaged in data correction; HS: Involved in methodology and editing.

ACKNOWLEDGEMENTS

The author acknowledges the help and permission provided by the Head of the Department of Veterinary Clinical Medicine, College of Veterinary and Animal science, Bikaner. We are thankful to the Dean, College of Veterinary and Animal science, Bikaner.

REFERENCES

Adolphe JL, Silver TI, Childs H, Drew MD and Weber LP, 2014. Short-term obesity results in detrimental metabolic and cardiovascular changes that may not be reversed with weight loss in an obese dog model. Br J Nutr, 112(4): 647-656, doi: 10.1017/S0007114514001214

Alpert MA, Terry BE, Hamm CR, Fan TM, Cohen MV *et al*., 2001. Effect of weight loss on the ECG of normotensive morbidly obese patients. Chest, 119(2): 507-510, doi: 10.1378/chest.119.2.507

Bach JF, Rozanski EA, Bedenice D, Chan DL, Freeman LM *et al*., 2007. Association of expiratory airway dysfunction with marked obesity in healthy adult dogs. Am J Vet Res, 68: 670-675, doi: 10.2460/ajvr.68.6.670

Braos AC, Zanluchi AT, Kemper B, Padilha FN and Trapp SM, 2009. Physical and epidemiologic aspects of canine obesity Ciênc Vet Tróp, 12:35-40

Burkholder W and Toll P, 2000. Obesity: In Small Animal Clinical Nutrition. Mark Morris Institute, Topeka, pp 401-430

Burkholder WJ and Bauer JE, 1998. Foods and techniques for managing obesity in companion animals. J Am Vet Med Assoc, 212(1): 658-662

Chandler ML, 2016. Impact of obesity on cardiopulmonary disease. Veterinary Clinics: Small Anim Pract, 46(5): 817-830, doi: 10.1016/j.cvsm.2016.04.005

Courcier EA, Thomson RM, Mellor DJ and Yam PS, 2010. An epidemiological study of environmental factors associated with canine obesity. J Small Anim Pract, 51(7): 362-367, doi: 10.1111/j.1748-5827.2010.00933.x

Creedon JMB and Davis H, 2012. Advanced

Monitoring and Procedures for Small Animal Emergency and Critical Care. 1st edn. Wiley Blackwell publishing by John Wiley & Sons

Fonfara S, de la Heras Alegret L, German AJ, Blackwood L, Dukes-McEwan JM *et al*., 2011. Underlying diseases in dogs referred to a veterinary teaching hospital because of dyspnoea: 229 cases (2003–2007). J Am Vet Med Assoc, 239(9): 1219-1224, doi: 10.2460/javma.239.9.1219

Granger JP, West D and Scott J, 1994. Abnormal pressure natriuresis in the dog model of obesity-induced hypertension. Hypertension, 23(1): 8-11, doi: 10.1161/01.HYP.23.1_Suppl.I8

Gurpreet, 2019. Risk factors and diagnosis of obesity in companion dogs. M.V.Sc Thesis submitted to Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana

Hall JE, 2003. The kidney, hypertension, and obesity. Hypertension, 41(3 Pt 2): 625-633, doi: 10.1161/01.HYP.0000052314.95497.78

Hotta K, Funahashi T, Bodkin NL, Ortmeyer HK, Arita Y *et al*., 2001. Circulating concentrations of the adipocyte protein adiponectin are decreased in parallel with reduced insulin sensitivity during the progression to type 2 diabetes in Rhesus monkeys. Diabetes, 50(5): 1126-1133, doi: 10.2337/diabetes.50.5.1126

Hynd PI, Czerwinski VH and Mcwhorter TJ, 2014. Obesity and core temperature in canines. Int J Obesity, 38(2): 231-235, doi: 10.1038/ijo.2013.110

Joles JA, 1998. Obesity in dogs: Effects on renal function, blood pressure, and renal disease. Vet Quarterly, 20(4): 117-120, doi: 10.1080/01652176.1998.9694854

Jose Lahm Cardoso M, Fagnani R, Zaghi Cavalcante C, de Souza Zanutto M, Júnior AZ *et al*., 2016. Blood pressure, serum glucose, cholesterol, and triglycerides in dogs with different body scores. Vet Med Int, 2016: 8675283, doi: 10.1155/2016/8675283

Jung DH, Kim JY, Kim JK, Koh SB, Park JK *et al*., 2014. Relative contribution of obesity and serum adiponectin to the development of hypertension. Diabetes Res Clin Pract, 103(1): 51-56, doi: 10.1016/j.diabres.2013.09.018

Kuruvilla A and Frankel TL, 2003. Heart rate of pet dogs: effects of overweight and exercise. Asia Pacific J Clin Nutr, 12: 51-51

Laflamme D, 1997. Development and validation of a body condition score system for dogs. Canine Pract, 22: 10-15

Laflamme DP, 2001. Challenges with weight-reduction studies. Compend Contin Educ Vet, 23: 45-50

Landsberg L, Young JB, Leonard WR, Linsenmeier RA and Turek FW, 2009. Do the obese have lower body temperatures? A new look at a forgotten variable in energy balance. Trans Am Clin Climatol Assoc, 120: 287

Lohmeier TE, Iliescu R, Liu B, Henegar JR, Maric-Bilkan C and Irwin ED, 2012. Systemic and renal-specific sympatho-inhibition in obesity hypertension. Hypertension, 59(2): 331-338, doi: 10.1161/HYPERTENSIONAHA.111.185074

Lund EM, Armstrong PJ, Kirk CA and Klausner JS, 2006. Prevalence and risk factors for obesity in adult dogs from private US veterinary practices, Intern J Appl Res Vet Med, 4: 177-186

Manens J, Bolognin M, Bernaerts F, Diez M, Kirschvink N *et al*., 2012. Effects of obesity on lung function and airway reactivity in healthy dogs. Vet J, 193(1): 217-221, doi: 10.1016/j.tvjl.2011.10.013

Martin M, 2007. Small Animal ECGs: An Introductory Guide, 2nd edn. John Wiley & Sons, pp 176

Massabuau P, Verwaerde P, Galinier M, Fourcade J, Rouge P *et al*., 1997. Left ventricular repercussion of obesity-induced arterial hypertension in the dog. Arch Cardiovasc Dis, 90(8): 1033-1035

McGreevy PD, Thomson PC, Pride C, Fawcett A, Grassi T *et al*., 2005. Prevalence of obesity in dogs examined by Australian veterinary practices and the risk factors involved. Vet Record, 156: 695-702, doi: 10.1136/vr.156.22.695

Mehlman E, Bright JM, Jeckel K, Porsche C, Veeramachaneni DNR *et al*., 2013. Echocardiographic evidence of left ventricular hypertrophy in obese dogs. J Vet Intern Med, 27(1): 62-68, doi: 10.1111/jvim.12018

Montoya JA, Morris PJ, Bautista I, Juste MC, Suarez L *et al*., 2006. Hypertension: A risk factor associated with weight status in dogs. J Nutr, 136(7): 2011-2013, doi: 10.1093/jn/136.7.2011S

Neto GB, Brunetto MA, Sousa MG, Carciofi AC and Camacho AA, 2010. Effects of weight loss on the cardiac parameters of obese dogs. Pesq Vet Bras, 30(2): 167-171, doi: 10.1590/S0100-736X2010000200012

Palatini P, 2011. Role of elevated heart rate in the development of cardiovascular disease in hypertension. J Hypertension, 58(5): 745-750, doi: 10.1161/HYPERTENSIONAHA.111.173104

Palatucci AT, Piantedosi D, Rubino V, Giovazzino A, Guccione J *et al*., 2018. Circulating regulatory T cells (Treg), leptin and induction of proinflammatory activity in obese Labrador Retriever dogs. Vet Immunol Immunopathol, 202: 122-129, doi: 10.1016/j.vetimm.2018.07.004

Pérez-Sánchez AP, Del-Angel-Caraza J, Quijano-Hernández IA and Barbosa-Mireles MA, 2015. Obesity-hypertension and its relation to other diseases in dogs. Vet Res Commun, 39(1): 45-51, doi: 10.1007/s11259-015-9630-9

Piantedosi D, Di Loria A, Guccione J, De Rosa A, Fabbri S *et al.*, 2016. Serum biochemistry profile, inflammatory cytokines, adipokines and cardiovascular findings in obese dogs. Vet J, 216: 72-78, doi: 10.1016/j.tvjl.2016.07.002

Piccione G, Giudice E, Fazio F and Refinetti R, 2011. Association between obesity and reduced body temperature in dogs. Int J Obes, 35(8): 1011, doi: 10.1038/ijo.2010.253

Ramsey I and Holden S, 2009. Advances in the management of obesity in dogs. Vet Nurs J, 24(1): 16-24, doi: 10.1080/17415349.2009.11013054

Ricci R, Gottardo F, Ferlito JC, Stefani A, Ravarotto L *et al.*, 2007. Body condition score (BCS) and metabolic status of shelter dogs. Ital J Anim Sci, 6(1): 859-861, doi: 10.4081/ijas.2007.1s.859

Robertson ID, 2003. The association of exercise, diet and other factors with owner-perceived obesity in privately owned dogs from metropolitan Perth, WA Prev Vet Med, 58(1-2): 75-83, doi: 10.1016/S0167-5877(03)00009-6

Rocchini AP, Moorehead CP, DeRemer S and Bondie D, 1989. Pathogenesis of weight-related changes in blood pressure in dogs. J Hypertens, 13(6 Pt 2): 922-928, doi: 10.1161/01.HYP.13.6.922

Salome CM, King GG and Berend N, 2009. Physiology of obesity and effects on lung function. J Appl Physiol, 108(1): 206-211, doi: 10.1152/japplphysiol.00694.2009

Simpson JW, Anderson RS and Markwell PJ, 1993. Clinical nutrition of the dog and cat. Blackwell Scientific Publications, pp 151

Snedecor GW and Cocharan WG, 2004. Statistical methods, 8th edn. Low State University Prees, USA, Oxford and IBH publication, New Delhi, pp 591

Sorvoja H and Myllyla R, 2006. Noninvasive blood pressure measurement methods. MQA, 27: 239-264

Stepien RL and Rapoport GS, 1999. Clinical comparison of three methods to measure blood pressure in non sedated dogs. J Am Vet Med Assoc, 215(11): 1623-1628

Truett AA, Borne AT, Monteiro MP and West DB, 1998. Composition of dietary fat affects blood pressure and insulin responses to dietary obesity in the dog. Obes Res, 6(2): 137-146, doi: 10.1002/j.1550-8528.1998.tb00328.x

Tvarijonaviciute A, Ceron JJ, Holden SL, Cuthbertson DJ, Biourge V *et al.*, 2012. Obesity-related metabolic dysfunction in dogs: A comparison with human metabolic syndrome. BMC Vet Res, 8(1): 147, doi: 10.1002/j.1550-8528.1998.tb00328.x

Van Vliet BN, Hall JE, Mizelle HL, Montani JP and Smith Jr MJ, 1995. Reduced parasympathetic control of heart rate in obese dogs. Am J Physiol, 269(2): H629-H637, doi: 10.1152/ajpheart.1995.269.2.H629

Veiga AP, Price CA, de Oliveira ST, dos Santos AP, Campos R *et al.*, 2008. Association of canine obesity with reduced serum levels of C-reactive protein. J Vet Diagnostic Invest, 20(2): 224-228, doi: 10.1177%2F104063870802000214

Verwaerde P, Sénard JM, Galinier M, Rouge P, Massabuau P *et al.*, 1999. Changes in short-term variability of blood pressure and heart rate during the development of obesity-associated hypertension in high-fat fed dogs. J Hypertension, 17(8): 1135-1143

Weeth LP, Fascetti AJ, Kass PH, Suter SE, Santos A *et al.*, 2007. Prevalence of obese dogs in a population of dogs with cancer. Am J Vet Res, 68(4): 389-398, doi: 10.2460/ajvr.68.4.389

Wolf R, Camacho AA and Souza RCA, 2000. Computerized electrocardiograph in Beagle dogs. Brazilian J Vet Anim Sci, 52(6): 610-615

Received- 09.06.2022, Accepted- 28.04.2023, Published- 26.05.2023 (Online), 01.06.2023 (Print)
Section Editor: Prof. S. K. Nandi, Associate Editor