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Biochemical and hormonal parameters changes in canine obesity

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Abstract
The present study was carried out to evaluate biochemical and hormonal parameters changes in dogs. A total of 210 adult dogs irrespective of age, sex and breed were screened for obesity. The adult dogs weighing more than 15 per cent of their ideal body weight were considered for the study and body condition score was assigned as whole number value 1 to 9 and dogs with BCS 8 to 9 were considered as obese. The biochemical parameters viz. albumin, ALT and ALP, serum glucose, total protein, albumin, total cholesterol, total triglyceride, HDL-C, LDL-C and VLDL-C were significantly higher in obese dogs whereas non-significant difference was found in globulin, AST, BUN and serum creatinine in obese dogs as compared to apparently healthy dogs. There was no significant difference in mean values of serum T3, T4, TSH in obese dogs as compared to apparently healthy dogs.

Keywords: Dog obesity, biochemical, hormonal, cholestrol

Introduction
Obesity has emerging challenge at global level to the practicing veterinarians and pet-owners which requires newer methods of diagnosis and treatment approaches for its effective control as it impact on quality of life (Churchill and Ward, 2016 and Shah *et al*., 2017) [13, 59] and longevity (Lawler *et al*., 2005 and Pereira-Neto *et al*., 2018) [33, 49]. Obesity could deteriorate the quality of life in pets as well shorten the life span (German, 2006) [20] by predisposing to several other diseases such as osteoarthritis, laminitis (Impellizeri *et al*., 2000 and Marshall *et al*., 2009) [22, 36] (chronic inflammation, hepatic lipidosis and diabetes mellitus (Ettinger *et al*., 1995; Kealy *et al*., 2002 and Rand *et al*., 2004) [15, 28 54]. Obesity in dogs may be associated with dysfunction in multiple organ systems (Radin *et al*., 2009) [53] such as cardiopulmonary diseases (Kume *et al*., 2009 and Bach *et al*., 2007) [29, 2], glucose intolerance, oxidative stress (Laflamme, 2012) [32] and other endocrine disorders (Zoran, 2010) [73].
In obesity hyper-lipidemia is a common finding, which is characterized by hypercholesterolemia and/or hyper-triglycemia. Hyperlipidemia can be caused by a quantitative increase in circulating lipoproteins (LP) or by a higher lipid concentration in the various LP classes (Mori *et al*., 2011) [39]. There are increased levels of cholesterol, triglycerides, high density lipoproteins cholesterol (HDL-C), low density lipoproteins cholesterol (LDL-C), glucose and blood urea nitrogen along with increased levels of aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP) and gamma glutamyl transferase (GGT) in overweight and obese dogs (Tribuddharatana *et al*., 2011) [63].
Many pet owners do not know if the dog is obese, or reason for causative conditions, or do not know why it is dangerous for health of their pets, so they do not spontaneously seek veterinary advice and thus it becomes the duty of the veterinarian to increase the owners' awareness and knowledge about obesity and how the dog is kept at normal body condition, convince owner about ill effects of the obesity and its management and control. Therefore, it becomes imperative to increase the awareness of companion animal obesity as a serious medical concern within the veterinary profession. Keeping in view the above facts, the present study was planned.

Materials and Methods
Source of Animals
The present study entitled Biochemical and Hormonal Parameters Changes in Canine Obesity

was conducted on adult dogs presented for routine clinical examination/ vaccination in canine out door of 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. Dogs were considered as obese when body weight excess optimum weight for body size by fifteen per-cent (Simpson *et al*., 1993; Laflamme, 2001) [60, 31]. Body condition score were assigned as whole number value 1 to 9 at the time of visual examination and palpation system (Laflamme, 1997; Burkholder and Toll, 2000) [30, 10]. Four classes of BCS were considered: BCS 1 to 3 (Lean dogs), BCS 4 to 5 (Ideal dogs), BCS 6 to 7 (Overweight dogs) and BCS 8 to 9 (obese dogs) by Ricci *et al*. (2007) [55] In present study dogs with BCS 8 to 9 were considered as obese.

On the basis of body condition score, a minimum of eighteen obese dogs were undertaken for the present study for biochemical and hormonal parameters estimation. Six apparently healthy dogs irrespective of age, sex, breed and excluded from the obesity base on selection criteria were also be taken as control for this study.

Collection of blood samples

After clinical examination of obese dogs, 5.0 ml of blood sample were collected aseptically in sterile syringe from cephalic vein and out of which, 2.0 ml blood was transfer aseptically in EDTA vacutainer for haematological analysis and another 3.0 ml blood was transfer in vacutainer without anticoagulant for biochemical and hormonal assay. The blood slants were made and incubated for 1 hour at 37 ^{0}C. Blood clots were broken and tubes were centrifuged at 2,500 rpm for 30 min. The serum was pipette out in small Pyrex tubes and transported to laboratory and kept immediately in the deep freeze at -20 ºC for serum biochemical estimations and hormonal Assay. Blood samples were collected from all obese dogs and as well as apparently healthy dogs at 60 days interval, taking 0 day as pre-treatment and 60th day as post-treatment for haemato-biochemical estimations.

History

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

Biochemical parameters estimations

Biochemical analysis of serum was carried out to estimate some of the biochemical parameters viz. serum glucose, serum total protein, albumin, globulin, serum creatinine, blood urea nitrogen, total cholesterol, High density lipoprotein cholesterol (HDL-C) and triglyceride concentrations, and the activities of aspartate aminotransferase (AST), alanine aminotransferase (ALT) and alkaline phosphatase by the standard method. Serum low density lipoprotein cholesterol (LDL-C) and very low density lipoprotein cholesterol (VLDL-C) concentrations was calculate by Friedewald formula. All the above biochemical parameters were estimated by using the IDEXX Vet Test Chemistry Analyzer. The principles, reagents required, procedure, calculation and precautions used for each of them were followed as per operator's manual.

Hormonal Assay

Hormonal assay of serum was carried out to estimate T3, T4 and TSH concentrations by ELISA Kit method.

Results and Discussion

Biochemical Parameters

The Mean ± SE values of biochemical parameters of obese dogs and apparently healthy dogs are presented in Table 1.

Tables and Figures

Table 1: Mean ± SE values of biochemical parameters of obese dogs and apparently healthy dogs

S. No.	Parameters	Obese dogs (n=18)	Apparently healthy dogs (n=6)	Statistical analysis (T test)
1	Glucose (mg/dl)	120.44±2.98	88.16±4.43	**
2	Total Protein (g/dl)	7.92±0.15	6.51±0.42	**
3	Albumin (g/dl)	4.01±0.10	3.41±0.11	*
4	Globulin (g/dl)	3.90±0.09	3.10±0.34	NS
5	ALT (IU/L)	72.41±4.54	54.67±5.28	*
6	AST (IU/L)	27.18±1.19	25.43±3.28	NS
7	ALP (IU/L)	126.94±9.73	70.83±2.44	*
8	BUN (mg/dl)	15.21±0.65	14.71±1.18	NS
9	Creatinine (mg/dl)	0.96±0.06	0.90±0.07	NS
10	Total Cholesterol (mg/dl)	285.33±9.17	158.03±22.02	**
11	Total triglyceride (mg/dl)	141.83±6.30	91.80±8.37	**
12	HDL-C (mg/dl)	122.61±6.14	91.16±8.24	**
13	LDL-C (mg/dl)	134.35±10.85	48.50±15.53	**
14	VLDL-C (mg/dl)	28.37±1.26	18.36±1.67	**

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

Serum Glucose (mg/dl)

The mean ± SE value of serum glucose (mg/dl) in obese dogs and apparently healthy dogs were 120.44±2.98 and 88.16±4.43, respectively. There was highly significant (p<0.01) increase in the serum glucose in obese dogs as compared to healthy dogs. Tribuddharatana *et al*., (2011) [63], Verkest *et al*., (2012) [70], Adolphe *et al*., (2014) [1], Pena *et al*., (2014) [47], Fernoaga *et al*., (2016) [16] and Tvarijonaviciute *et al*., (2019) [67] also reported statistically significant higher value of glucose in obese dogs. It has been reported that in obese individual, intra-abdominal adipose tissue release increased amounts of non-esterified fatty acids (NEFAs), hormones (adiponectin, leptin) and pro-inflammatory cytokines (tumor necrosis factor α, interleukin-

6), factors that are involved in the development of insulin resistance. In the insulin resistance state, the β-cell dysfunction is observed with a defect in insulin release result in suppression of hepatic glucose uptake in muscle which, in turn, leads to increase plasma glucose levels (Kahn *et al*., 2006) [27]. Hyperglycemia in present study might be due to obesity induce insulin resistance. The increase of insulin secretion and impairment of its action leads to an alteration in energy metabolism and contributes to chronic hyperglycemia (Yamka *et al*., 2006, Vaiga *et al*., 2008, Verkest *et al*., 2012, Serisier *et al*., 2008, Baric Rafaj *et al*., 2016 and Tvarijonaviciute *et al*., 2019) [71, 69, 70, 4, 66].

Total serum protein (g/dl)

The mean ± SE values of total serum protein (g/dl) in obese dogs and apparently healthy dogs were 7.92±0.15 and 6.51±0.42, respectively. The mean value of total serum protein were highly significant (p<0.01) in obese dogs as compared to healthy dogs. Similar findings were also reported by Yamka *et al*., (2006) [71], Piantedosi *et al*., (2016) [50], Radakovich *et al*., (2017) [52], Gurpreet (2019) [21] and Tvarijonaviciute *et al*., (2019) [65] who found significantly higher value of total protein in obese dogs. Higher serum total protein in the obese dogs may be attributed to decreased serum water fraction, antigenic stimulation or increased protein catabolism associated with a larger body mass (Radakovich *et al*., 2017) [52]. Li *et al*., (2012) [34] also reported that body fat percentage is positively correlated with total protein.

Serum Albumin (g/dl)

The mean ± SE values of serum albumin (g/dl) in obese dogs and apparently healthy dogs were 4.01±0.10 and 3.41±0.11, respectively. The mean value of serum albumin was significantly (p<0.05) higher in obese dogs as compared to healthy dogs. This present finding are in line with Yamka *et al*., (2006) [71], Linder *et al*., (2013) [35], Gurpreet (2019) [21] and Tvarijonaviciute *et al*., (2016) [66] who also reported higher levels of albumin in obese dogs. Studies in humans have also reported increased albumin in overweight and morbidly obese patients (Yoo *et al.*, 2010, Sirico *et al.*, 2012 and Benabdelkamel *et al.*, 2015) [72, 61, 7] The possible reason for higher level of albumin in obese dogs could be related to the hyperplasia and hypertrophy of adipose tissue (Benabdelkamel *et al.*, 2015; Sirico *et al.*, 2012; Yoo *et al.*, 2010) [7, 61, 72] Increased albumin is typically accredited to dehydration and this increased production can also be stimulated by insulin, corticosteroids, sex hormones, thyroxine and growth hormone (Nicholson *et al.*, 2000) [45] The higher total calcium values are likely to be associated with the higher albumin concentrations in obese dogs. As the majority of calcium found in blood is bound to albumin, changes in total calcium often reflect changes in albumin. Measuring ionized calcium would be valuable to confirm this interpretation (Radakovich *et al.*, 2017) [52]

Serum Globulin (g/dl)

The mean ± SE values of serum globulin (g/dl) in obese and apparently healthy dogs were 3.90±0.09 and 3.10±0.34, respectively. The mean value of serum globulin in obese dogs were found no significant difference when compare to mean value of apparently healthy dogs.

This present finding is in accordance with the finding of Yamka *et al*., (2006) [71], Gurpreet (2019) [21] and Nandini *et al*., (2012) [43] who also reported that there was no significant difference (P≤0.05) in levels of total globulin between control healthy dogs and obese dogs during their studies.

Serum Alanine Aminotransferase (ALT) (IU/L)

The mean ± SE value of serum alanine aminotransferase (IU/L) in obese dogs and apparently healthy dogs were 72.41±4.54 and 54.66±5.28, respectively. There was a significant (p<0.05) increase in the mean value of ALT in obese dogs as compare to healthy control dogs.

The finding of present investigation is in accordance with finding of Pena *et al.* (2008) [48], Tribuddharatana *et al*., (2011) [63], Piantedosi *et al*., (2016) [50] and Tvarijonaviciute *et al*., (2019) [66]. Significantly higher serum concentrations of alanine aminotransferase (ALT) may also be associated with higher prevalence of nonalcoholic fatty liver disease (NAFLD) as observed in obese humans (Choi, 2003) [12]. However the present finding is contrary to the finding of Mori *et al.* (2013) [40], Baric Rafaj *et al.*, (2016) [4] and Belotta *et al.*, (2018) [6] who found no difference in serum liver enzymes such as ALT, AST and GGT in obese dogs. Chen *et al.* (2008) [11], Saely *et al*., (2008) [57] and Tvarijonaviciute *et al*., (2019) [65] have reported a strong relation between hepatic enzymes (ALT, GGT) and metabolic syndrome. Thus, our finding suggests that dog with obesity related metabolic diseases have mildly altered liver functions.

Serum Aspartate Aminotransferase (AST) (IU/L)

The mean ± SE value of serum aspartate aminotransferase (IU/L) in obese dogs and apparently healthy dogs were 27.18±1.19 and 25.43±3.28, respectively. Non-significant difference (p>0.05) was observed in mean value of AST in obese dogs as compare to healthy control dogs, which were in agreement with the findings of Tribuddharatana *et al*., (2011) [63], Nandini *et al*., (2012) [43], Mori *et al*., (2013) [40], Baric Rafaj *et al.*, (2016) [4], Gurpreet (2019) [21] and Tvarijonaviciute *et al*., (2019) [65] who also found no difference in AST values between obese and non-obese dogs.

Serum Alkaline Phosphatase (ALP) (IU/L)

The mean ± SE value of serum alkaline phosphatase (IU/L) in obese dogs and apparently healthy dogs were 126.94±9.73 and 70.83±2.44, respectively. The mean value of ALP of obese dogs was found significantly higher (p<0.05) when compared to mean value of apparently healthy dogs.

Similar findings were also reported by Tribuddharatana *et al*., (2011) [63], Linder *et al.*, (2013) [35] and Baric Rafaj *et al*., (2016) [4]. The finding is however, contrary to Yamka *et al*., (2006) [71], Nandini *et al*., (2012) [43], Mori *et al.*, (2013) [40] and Gurpreet (2019) [21], Who also found there was no significant difference in levels of ALP between obese and normal weight groups of dogs. Similar increase activity of ALP was observed in obese rat by Mozes *et al*., (2004) [42] and concluded that changes in ALP activity might be due over nutrition. Alkaline phosphatase, as an enzyme functionally involved in fat absorption and the transport of long chain fatty acids in the intestinal mucosa (Bernard *et al*., 1992) [8] could be elevated in overweight and obese dogs due to overfeeding.

Blood Urea Nitrogen (BUN) (mg/dl)

The mean ± SE value of blood urea nitrogen (mg/dl) in obese dogs and apparently healthy dogs were 15.21±0.65 and 14.71±1.18, respectively. There was non-significant (p>0.05) difference in mean value of blood urea nitrogen in obese dogs

as compared with healthy control dogs. These finding were in line with Yamka *et al.,* (2006) [71], Nandini *et al.,* (2012) [43], Gurpreet, (2019) [21] and Tvarijonaviciute *et al*., (2019) [65] who also found a non-significant difference in mean value of BUN in obese dogs compare to healthy control group of dogs. Whereas, the present finding is contrary to the finding of Tribudhharatana *et al.,* (2011) [63] and Li *et al.,* (2012) [34] who reported significant increase in BUN concentration with increase in obesity.

Serum Creatinine (mg/dl)

The mean ± SE value of serum creatinine (mg/dl) in obese dogs and apparently healthy dogs were 0.96±0.06 and 0.90±0.07, respectively. Finding of present investigation revealed that there was no significant difference ($p>0.05$) in mean value of serum creatinine in obese dogs as compare to healthy control dogs, which also supported the findings of Tribuddharatna *et al.,* (2011) [63], Nandini *et al*., (2012) [43], Tvarijonaviciute *et al.* (2013) [65] and Gurpreet, (2019) [21]. In contrary to the finding of present study, Baric Rafaj *et al.* (2016) [4] and Yamka *et al.* (2016) [71] found lower level of creatinine in obese dogs.

Lipid Profile

The Mean ± SE values of lipid profile of obese dogs and apparently healthy dogs are presented in Table 1 Appendix XVII, XVIII and depicted.

Total Cholesterol (mg/dl)

The mean ± SE values of total cholesterol (mg/dl) in obese dogs and apparently healthy dogs were 285.33±9.17 and 158.03±22.09, respectively. The mean value of total cholesterol were significantly high ($p<0.01$) in obese dogs as compared to healthy dogs. The finding in the present study were in accordance with earlier reports of Diez *et al.,* (2004) [14], Jeusette *et al.,* (2005) [24], Yamka *et al.,* (2006) [71], Pena *et al*., (2008) [47], Stone *et al.,* (2009) [62], Tribuddharatna *et al.,* (2011) [63], Nandini *et al.,* (2012) [43], Verkest *et al*., (2012) [70], Usui *et al.,* (2016) [68], Baric Rafaj *et al*., (2016) [4] Gurpreet, (2019) [21] and Tvarijonaviciute *et al*., (2019) [66] who also found higher mean value of total cholesterol ($p<0.05$) in obese dogs as compared to normal weight dogs. Ricci *et al.,* (2007) [55], Montoya *et al*., (2017) [37], Park *et al.,* (2014) [46], Gebin *et al*., (2012) [19] and Piantedosi *et al*., (2016) [50], Jose Lahm Cardoso *et al.,* (2016) [26] also reported that obese dogs had significantly higher levels of total cholesterol and total triglycerides.

Total Triglyceride (mg/dl)

The mean ± SE values of total triglyceride (mg/dl), in obese dogs and apparently healthy dogs were 139.83±6.30 and 91.80±8.37, respectively. The mean value of total triglycerides were highly significant ($p<0.01$) in obese dogs as compared to healthy dogs. Jeusette *et al*., (2005) [24], Poppl *et al.,* (2005) [51], Ricci *et al.,* (2007) [55], Pena *et al.,* (2008) [47], Serisier *et al*. (2008) [58], Nandini (2010) [44], Gurpreet, (2019) [21], Park *et al.,* (2014) [46], Usui *et al*., (2016) [68], Jose Lahm Cardoso *et al.,* (2016) [26], Piantedosi *et al.* (2016) [50] Baric Rafaj *et al*. (2016) [4], Mosallanejad *et al*., (2018) [41] and Tvarijonaviciute *et al*., (2019) [65] also reported significantly ($p<0.01$) higher values of triglyceride in obese dogs compare to the control healthy dogs.

High Density Lipoprotein-C (HDL-C) (mg/dl)

The mean ± SE values of HDL-C (mg/dl) in obese dogs and apparently healthy dogs were 122.61±6.14 and 91.16±8.24, respectively. The mean value of total cholesterol were significantly high ($p<0.01$) in obese dogs as compared to healthy dogs. This finding is in agreement with Jeusette *et al*., (2005) [24], Pena *et al.,* (2008) [47], Mori *et al*., (2011) [38], Nandini *et al.,* (2012) [43], Usui *et al*., (2016) [68], Tropf *et al*., (2017) [64] and Gurpreet, (2019) [21] who also found high serum HDL level in obese dogs.

Low Density Lipoprotein-C (LDL-C) (mg/dl)

The mean ± SE values of LDL-C (mg/dl), in obese dogs and apparently healthy dogs were 134.35±10.85 and 48.50±15.53, respectively. The mean value of LDL-C was significantly higher ($p<0.01$) in obese dogs as compared to healthy dogs. The present study finding is in agreement with Jeusette *et al*., (2005) [24], Yamka *et al*., (2006) [71], Mori *et al*., (2011) [39], Tribuddharatana *et al.,* (2011) [63], Nandini *et al*., (2012) [43], Piantedosi *et al*., (2016) [50] and Gurpreet, (2019) [21] who also found higher serum LDL value in obese dogs compare to normal weight dogs.

Very low density lipoprotein-C (VLDL-C) (mg/dl)

The mean ± SE values of VLDL-C (mg/dl), in obese dogs and apparently healthy dogs were 28.36±1.26 and 18.36±1.67, respectively. The mean value of VLDL-C were highly significantly high ($p<0.01$) in obese dogs as compared to healthy dogs. The present finding is in accordance with Jeusette *et al*., (2005) [24], Mori *et al*., (2011) [38], Nandini *et al*., (2012) [44], Usui *et al*., (2016) [68] and Gurpreet (2019) [21] who also found higher serum VLDL value in obese dogs compare healthy dogs. It is difficult to determine whether increases in blood lipid concentrations were the result of obesity or high energy intake. Indeed, obese dogs consumed significantly more food than lean dogs, although their body weight was stable (Jeusette*et al*., 2005) [24]. In humans, insulin resistance and compensatory hyper insulinemia promote enhanced production of triglycerides and cholesterol-rich lipoproteins by the liver, mainly VLDL triglyceride and LDL cholesterol. (Bierman and Chait, 1988) [9]

Mori *et al*., (2011) [38] and Nandini *et al*., (2012) [43] also observed that increased feed intake along with sedentary lifestyle led to increased energy intake resulting increased levels of triglycerides and cholesterol or alteration in lipid profile. Barrie *et al*., (1993) [5] and Gebin (2012) [18] reported that body fat percentage correlated positively with total cholesterol and total triglycerides which tends to increase as a result of increasing adiposity. Increased amount of VLDL-triglycerides also causes increase in VLDL-cholesterol concentration. In addition, hepatic lipase activity can also lead to high HDL-C concentrations in blood. The increase in level of triglycerides is also due to increase in the production of triglyceride rich lipoprotein and decrease catabolism of these proteins. Abnormal insulin activity results in increased lipolysis in adipose tissue leading to release of increased fatty acids which repack back into triglycerides in liver (Bailhache *et al*., 2003) [3].

Gayet *et al.* (2004) [17] reported the role of insulin resistance in obesity resulting in dyslipedemia, as observed in human beings and other 72 species. Isabelle *et al*., (2005) [23] suggested that triglyceridemia and cholestrolemia is due to increased lipid concentration in all lipoprotein fractions. Increased amount of VLDL-triglycerides also causes increase

in VLDL-cholesterol concentration. In addition, hepatic lipase activity can also lead to high HDL-C concentrations in blood (Barrie *et al*., 1993) [5]. Jhonson, (2005) [25] reported that increase in obesity markers could be due to cumulative effect of daily feeding of high-fat diets which increases production of chylomicrons by intestinal epithelium resulting in obesity and abnormal insulin resistance (Rocchini *et al*., 1987) [56].

Hormonal Assay

In present study out 38 obese dogs, 3 dogs were found positive for hypothyroidism and these dogs were excluded from the study. The Mean ± SE values of T3 (ng/dl), T4 (nmol/L) and TSH (ng/ml) of obese dogs and apparently healthy dogs are presented in Table 2.

Table 2: Mean ± SE value of T3 (ng/dl), T4 (nmol/L) and TSH (ng/ml) of obese dogs and apparently healthy dogs.

S. No.	Parameters	Obese dogs (n-18)	Apparently healthy dogs (n-6)	Statistical analysis (T test)
1	T3	93.33±2.98	83.85±8.10	NS
2	T4	36.12±1.98	31.62±4.09	NS
3	TSH	0.24±0.003	0.22±0.01	NS

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

The mean ± SE values of T3, T4 and TSH obese dogs were 93.33±2.98, 36.12±1.98 and 0.24±0.003, respectively whereas, corresponding values in apparently healthy dogs were 83.85±8.10, 31.62±4.09, 0.22±0.01, respectively. There was no significant (P≤0.05) difference in mean values of T3, T4 and TSH of obese dogs as compared to mean values of these variables in apparently healthy dogs in the findings of present study.

This finding is in confirmatory with finding of Park *et al*. (2014) [46] and Gurpreet (2019) [21] who also reported non-significant difference in T4 and TSH concentration in obese dogs, respectively.

Conclusions

The present study was conducted to estimate biochemical and hormonal changes in dogs suffering with obesity. The biochemical parameters revealed that mean values of serum glucose, total protein, albumin, total cholesterol, total triglyceride, HDL-C, LDL-C, VLDL-C were significantly higher (p<0.01) in obese dogs as compared to apparently healthy dogs and the mean values Albumin, ALT and ALP were significantly (p<0.05) higher in obese dogs as compared to apparently healthy dogs whereas non-significant difference was found in mean values of AST, BUN, serum creatinine, globulin in obese dogs as compared to apparently healthy dogs. There was no significant difference in mean values of serum T3, T4, TSH in obese dogs as compared to apparently healthy dogs.

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