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Impact of Thermal Stress on Health Signs, Hormones Levels, Hematological and Biochemical Parameters of Police Dogs in Iraq

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Abstract | This study was conducted to determine the changes in health signs, hormones levels, haematological and biochemical parameters of Police dogs exposed to thermal stress. A total of 40 police dogs, 3-6 years old were used in this study that extended for 7 months. The dogs were randomly distributed into four groups (10 per group). Group 1 was exposed to an environmental temperature 15 ˚C (control group), while group 2, 3 and 4 were subjected to higher environmental temperature of 25 ˚C, 35 ˚C and 45 ˚C, respectively to induce thermal stress. Health signs including rectal temperature, respiratory rate, and heart rate were measured. Hematological and biochemical parameters were assayed. Vitamin C and Immunoglobulin IgG were also measured. In addition, hormones levels involving T3, T4 and GH hormones were determined. The results of this study showed that health signs, vitamin C, IgG, ALT and AST levels significantly increased in group 4. However, RBCs, PCV, and also the total cholesterol, triglycerides, total protein, albumin, growth hormone, T3 and T4 levels were decreased in group 4 than control. A progressive significant increase in blood sugar levels in group 2, 3 and 4 compared with the control group. In conclusion, this study demonstrated that exposing Police dogs to thermal stress with temperature up to45˚C could negatively affect health signs, hormones levels, hematological and biochemical parameters, which might reflect adversely on the dog`s performance and their ability to do their tasks perfectly.

Keywords | Police dogs, Thermal stress, Biochemical parameters, Hormones traits.

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INTRODUCTION

Dogs have been used by humans for many thousands of years for varying purposes including hunting, guarding, warfare, detecting drugs, and searching for missing people in earthquakes and blazes (Okusanya et al., 2014). The average age of the dog ranged between 8-12 years old depending on the environment in which it is living. It was noted that hot climates and high relative humidity environments could lead to disturbance in animal movement, decreases their growth rates and daily feed intake with increase in water consumption, thus, finally led to alteration of the feed conversion efficiency and general health status (Miller, 2018).

Thermal stress is defined as the temperature range at which the animal suffers and may lead to a decrease in the feed consumption rates with increase in the amounts of drinking water (Mohammad, 2000; Miller, 2018). It is well known that the average temperature of dogs is 37.5-38.8 ˚C and have the ability to regulate their body temperature by the nervous system and get rid of excess heat from the body through radiation. However, thermal stress is more common in dogs (Beeson, 1999). In tropical hot climate countries, such as Iraqi, dogs are often exposed to thermal stress especially during the summer season which has a negative effect on the biological activity of various body organs and lead to decrease in their performance (Ramadan, 2009).

The main clinical signs of thermal stress in dogs are high body temperature, physical inactivity, muscle twitching, and sudden dog breakdown when thermal stress is not fatal (Hoskins, 2000). Some studies indicated that the high-

er temperature of the surrounding environment the higher temperature of the rectum (Fahmi, 1999). Thus, Animal life becomes threatened when the temperature of the rectum is higher than the body's thermal balance. The animal's body cannot maintain its equilibrium when it reaches 42 °C (Thwaites, 2000). This lead to increase in heart rate and respiratory rate in animals, however, the normal respiration rate for dogs is 15-30 breaths / min (Radositis, 2010). On the other hand, blood biochemical parameters and hormones, such as blood sugar, liver functions, T3, T4 and GH hormones, could be significantly affected by thermal stress (Tavazzi et al., 2000). Since Police dogs are very important in the routine daily work, and limited information is available about the effect of Iraqi climate on the activity of these dogs. Therefore, this study was designed to investigate the effect of thermal stress on the physiological activities and blood biochemical traits of Police dogs at Hillah Police Directorate-Babil Governorate, Iraq.

MATERIALS AND METHODS

Animals and Experimental Design

Forty healthy police dogs, 3-6 years old belong to Hillah Police Department were used in this study. The study was conducted for 7 months in the period from 1/8/2016 and 1/3/2017. All procedures were approved by the Veterinary Clinic in Hillah, Babylon-Iraq. They were distributed into four groups (10 per group). Group 1 was exposed to an environment temperature 15 °C (control group), group 2, 3 and 4 were subjected to an increase in environmental temperature of 25 °C, 35 °C and 45 °C, respectively to induce thermal stress. Food and water were supplied *ad libitum*.

Measurements

Health signs: Rectal temperature, respiration rate and heart rate was determined

Hormones, Hematological and biochemical parameters: Blood sample about 5 ml were obtained directly from the cephalic vein, 2 ml were placed in EDTA tubes for hematological tests and the remaining 3 ml were used for collection of serum for biochemical tests. Blood sugar, total protein, albumin, globulin, cholesterol and triglycerides were assayed using special kits, Biolabo, French. While, liver enzymes (AST and ALT) were measured using ELISA kit (ABO, Swiss). Vitamin C and Immunoglobulin IgG were determined according to Al-Barody (2002). T3, T4 and GH hormones were assessed by radioimmunoassay method (Immunotech, Beckman Coulter, UK).

Statistical Analysis

Data were analyzed by analysis of variance (ANOVA) and the means were compared using the Duncan multiple test with determining of significance at $P< 0.05$ using statistical analysis software, SAS ver.9.3.

RESULTS

Health Signs

The results showed no significant differences in rectum temperature, heart rate and respiration rate of group 2 and 3 from control. While those in group 4 showed significantly higher values ($P\leq0.01$) when compared with control group (Table 1).

Table 1: Effect of different environmental temperatures on health signs of Police dogs

Health signs	Group 1 15 °C	Group 2 25 °C	Group 3 35°C	Group 4 45°C
Rectal temperature (°C)	37.97± 0.10^{b}	37.85± 0.09^{b}	38.17± 0.14^{b}	40.38± 0.14 ^{a}
Heart rate (pulse/min)	81.30± 1.35^{b}	81.20± 1.43^{b}	80.40± 0.92^{b}	97.00± 1.22^{a}
Respiration rate (breaths/min)	19.00± 1.20^{b}	18.60± 1.01^{b}	19.40± 0.90^{b}	26.00± 0.69^{a}

Means expressed as Mean±SD

Means within same row have different letters significantly difference at $P\leq0.01$.

Hematological Parameters

The red blood cell count (RBC) and packed cell volume (PCV) showed significant difference ($P\leq0.05$) in group 4 from control group. However, white blood cell count (WBC) and hemoglobin (Hb) was not affected in the same group. On the other hand, group 2 and 3 did not show any significant changes in all parameters, in comparison to the control group (Table 2).

Table 2: Effect of different environmental temperatures on hematological parameters of Police dogs

Hematological parameters	Group 1 15 °C	Group 2 25 °C	Group 3 35°C	Group4 45°C
RBC (1×10^{6})	6.47± 0.26^{a}	6.91± 0.24^{a}	7.10± 0.28^{a}	4.65± 0.13^{b}
WBC (1×10^{3})	9.82± 0.84^{a}	10.56± 1.15^{a}	9.26± 0.36^{a}	10.73± 0.73^{a}
PCV%	41.85± 1.41^{a}	41.70± 20^{a}	42.11± 1.50^{a}	33.05± 0.60^{b}
Hb (mg/dl)	14.84± 0.54^{a}	14.65± 0.59^{a}	14.66± 0.76^{a}	10.57± 0.32^{a}

RBC= red blood cell count, WBC= white blood cell count, Hb= hemoglobin, PCV= packed cell volume.

Means expressed as Mean±SD

Means within same row have different letters significantly difference at $P\leq0.01$.

Biochemical Parameters and Immunity

Biochemical profile presented in Table (3) declared the

progressive highly significant (P≤0.01) increase in the level of sugar with each increase in temperature more than comfortable 15˚C (control group), from 80 to 86, 91 and 98mg/dl respectively. On the other hand, the levels of triglycerides (P≤0.01), and cholesterol (P≤0.05) decreased significantly in group 4, while, vitamin C increased significantly (P≤0.01) when compared with control group. On the other hand, group 2 and 3 did not show any significant changes in triglycerides, cholesterol and vitamin C, in comparison to the control group.

Table 3: Effect of different environmental temperatures on biochemical parameters of police dogs

Biochemical parameters	Group 1 15 ˚C	Group 2 25 ˚C	Group 3 35˚C	Group4 45˚C
Blood sugar (mg / dl)	80.00 ± 1.69^{d}	86.20 ± 0.99^{c}	91.00 ± 1.76^{b}	98.00 ± 1.31^{a}
Cholesterol (mg / dl)	139.00 ± 6.58 ^{a}	139.20± 4.78^{a}	146.30 ± 5.83 ^{a}	92.20 ± 1.48 ^{b}
Triglycerides (mg / dl)	60.70 ± 3.73 ^{a}	59.30 ± 3.48 ^{a}	59.50 ± 2.70 ^{a}	31.30 ± 2.30 ^{b}
Vitamin C (mg / dl)	6.13 ± 0.27^{b}	6.42 ± 0.28^{b}	6.76 ± 0.32^{b}	8.91 ± 0.15 ^{a}

Means expressed as Mean±SD
Means within same row have different letters significantly difference at *P*≤0.01 or P≤0.05.

Total Protein and Liver Enzymes

Total protein and albumin show a significant (P≤0.01) reduction in dogs subjected to thermal stress of 45˚C (group 4) compared to the control. However, dogs in the 2nd and 3rd groups were able to tolerate and restored their protein and albumin values to those of the control group (Table 4). Although, it was not significant, there was a slight increase in the globulin level of group 4than other groups.

Immunity and liver were clearly affected by the higher temperature (45 ˚C) in the group 4 of dogs i.e. the level of thermal stress, and this was evident here by the significant (P≤0.01) increase of Immunoglobulin IGg and AST and ALT enzymes levels in comparison to the control group. Dogs in the 2nd and 3rd group were able to restore their IGg, AST and ALT values close to those of the control one (Table 4).

Hormones Levels

Table (5) showed that there were no significant differences between the 2nd and 3rd groups of dogs exposed to 25˚C and 35˚C on the concentration of growth and thyroid hormones from the control group. Rising the surrounding temperature to the dogs in the 4th group up to 45 ˚C and exposing dogs to thermal stress was responsible for the significant (P≤0.01) reduction in the concentration of growth hormone and thyroid hormones (T3 and T4) in comparison to the control group.

Table 4: Effect of thermal stress on blood proteins and immune system in dog groups (Average ± standard error).

Studied traits	First treatment (15˚C)	Second treatment (25˚C)	Third treatment (35˚C)	Fourth treatment (45˚C)
Numbers of dogs	10	10	10	10
Total protein (g / dl): **	6.06 ± 0.20 ^{a}	6.08 ± 0.21 ^{a}	6.25 ± 0.19 ^{a}	4.67 ± 0.09 ^{b}
Albumin (gm / dl): **	3.75 ± 0.21 ^{a}	3.90 ± 0.17 ^{a}	4.01 ± 0.13 ^{a}	1.80 ± 0.15 ^{b}
Globulins (g / d): NS	2.32 ± 0.25 ^{a}	2.23 ± 0.20 ^{a}	2.29 ± 0.23 ^{a}	2.87 ± 0.13 ^{a}
immunoglobulin IGg (mg / dl): **	803.60 ± 24.77^{b}	823.40 ± 21.46 ^{b}	809.30 ± 28.92 ^{b}	964.00 ± 20.29 ^{a}
ALT (mg / dl): **	63.60 ± 2.49 ^{b}	67.00 ± 2.51 ^{b}	65.30 ± 1.95 ^{b}	95.60 ± 1.25 ^{a}
AST (mg / dl): **	27.90 ± 3.06 ^{b}	31.80 ± 3.21 ^{b}	34.80 ± 2.79 ^{b}	43.80 ± 4.38 ^{a}

A trait that their averages have different horizontally letters indicates significant differences at the probability level (P≤0.01). NS: Not significant. * The differences were significant at the probability level of (P≤0.05). ** The differences are significant at the probability level of (P≤0.01).

Table 5: Effect of different environmental temperatures on the hormones concentration of police dogs

Hormones	Group 1 15 ˚C	Group 2 25 ˚C	Group 3 35˚C	Group 4 45˚C
Growth hormone (mg / dl)	49.00 ± 1.53 ^{a}	46.90 ± 2.34 ^{a}	48.78 ± 2.47 ^{a}	30.10 ± 0.90 ^{b}
T3 hormone (mg / dl)	2.65 ± 0.15 ^{a}	2.70 ± 0.16 ^{a}	2.73 ± 0.21 ^{a}	0.66 ± 0.12 ^{b}
T4 hormone (mg / dl)	3.72 ± 0.11 ^{a}	3.67 ± 0.13 ^{a}	3.59 ± 0.27 ^{a}	0.57 ± 0.12 ^{b}

Means expressed as Mean±SD
Means within same row have different letters significantly difference at *P*≤0.01

DISCUSSION

Health Signs

It is known that sympathetic vasoconstrictor nerves control the cutaneous vasomotor reactions to temperature changes. Thus, inhibition of the sympathetic vasoconstrictor tone causes peripheral vasodilation, which increases heat loss. This inhibition of is mediated by an increase in hypothalamic temperature or reflexively through thermo- receptors in the skin. However, when external temperature exceeds

tolerant level, heat is no longer lost by cutaneous vasodilation (Drobatz, 2015). As blood is shunted to the peripheral vessels (capillaries), there is a large decrease in circulatory blood volume. Eventually, if there is no compensatory increase in blood volume, thus, occur dilation of the heart and impaired cardiac efficiency, and finally impairment of respiratory centers. Thus, tissue edema and hypoxia can develop which are most serious in such areas as the lungs and brain.

The kidney can also be affected by shock-induced ischemia (Klein, 2012). The significant increase in these signs could be attributed to the effect of thermal stress that induces an increase in the speed of the external blood circulation, as usually used by most animals in sweat production to moisturize their bodies in an attempt to alleviate the negative effect of thermal stress through the process of evaporation, besides the thermos-polypnea process which help in exit of water vapor (Drobatz, 2015).

The results obtained agreed with Spealman, (2000) and Shapiro et al. (2015) who found a significant differences in the average rectal temperatures, heart rate and respiration rates when using different degrees of thermal stress in dogs, however, it disagreed with Weber (2001) and Kew (2005), who found no significant effect for thermal stress on these health signs.

Hematological Parameters

Exposure of animals to high environmental temperature stimulates the peripheral thermal receptors to transmit suppressive nerve impulses to the appetite center in the hypothalamus causing the decrease in feed consumption (Wojtas et al., 2014) That could be the most acceptable explanation to the effect of thermal stress on dogs in the 4th group as the decrease in feed consumption result in malabsorption of essential elements for red blood cells formation like cobalt (Taha, 1998; Alkam, 1999), and also the reduction in the concentration of thyroxin, plays a role in reduction of RBC production (Abdel Aziz, 2000). The reduced PCV could be regarded as a consequence sequel to the reduction in RBC.

Biochemical Parameters and Immunity

Blood sugar was significantly increased in the 4th group when dogs were exposed to higher thermal stress of 45 °C, this could be attributed to the result of glycogenolysis and glucose production from non-carbohydrate sources (glycogenesis) (Dehghan, 2003), which is in agreement with Ganong et al. (2011) who found a significant increase on the blood sugar under thermal stress. Also, stress induces cortisol secretion from the adrenal gland leading to glycolysis thus increase blood sugar level.

Vitamin C was significantly increased in the 4th group when dogs were exposed to higher thermal stress of 45 °C, which is a normal result of stress condition compared to the control group. The obtained changes in triglycerides and cholesterol levels may be due to a defect in the activity of the thyroid as low thyroxin concentration so lower metabolic rate. This results agreed with Chandra et al. (2009) who observed a significant decrease in cholesterol and triglyceride levels by increasing the intensity of thermal stress compared with control in dogs. Ganong et al. (2011) found a significant effect of thermal stress on the average of blood sugar, triglycerides, cholesterol and vitamin C in animals treated with thermal stress compared to control group. On contrary, Guida, (2010), showed no significant differences in the average of the above traits among groups of treated dogs with varying degrees of thermal stress.

Total Protein and Liver Enzymes

A significant decrease in the average concentrations of total blood protein and albumin levels were obtained when increasing the thermal stress level from 15 °C to 45 °C in the 4th group of dogs that could be due to protein degradation as a result of high level of corticosteroids in blood and the formation of sugar from non-carbohydrate sources (Repetto, 2014). According to the fact that the high temperature directly affects the process of thermal regulation in the body of the organism, causing inhibition of blood circulation and shrinkage and constriction in the capillaries in the internal organs especially the liver and spleen, that leads to destruction of liver cells which could reflected the increase in concentrations of AST and ALT in animals exposed to thermal stress (Saper, 2003). Tissue enzyme systems operate effectively over a narrow range of temperature. When this range is exceeded, widespread cellular damage and death of various tissues occurs. These findings were consistent with Tavazzi et al. (2000) who recorded that there were significant differences in the averages of total protein, albumin, globulin, ALT and AST enzymes in dogs under thermal stress, also in rats (Agrawal and Gupta, 2013; Hekal, 2015), and rabbits (Hekal, 2015), who referred to the increase in liver enzymes during thermal stress.

Hormones Levels

The concentration of growth and thyroid hormones showed a significant reduction in their values in dogs subjected to thermal stress of 45°C (4th group) compared with others. The possible explanation to these findings may be related to the reduction in daily feed intake and the malabsorption of the nutrients offered to them, which may be insufficient for the maintenance, growth and reproduction of animals exposed to heat stress compared to animals exposed to comfortable temperature. These results were consistent with Wang, (2000), who showed a significant effect of thermal stress on GH, T3 and T4 hormone concentrations, however, not in consistent with Yamashita, (2014),

who reported that the concentration of these hormones was not significantly affected when exposed animals to different degrees of thermal stress.

CONCLUSION

It was concluded from the obtained results that thermal stress to dogs, especially with temperature of 45°C could negatively affect all the physiological and biochemical parameters of the exposed dogs, as the mechanism of thermal regulation become ineffective in dissipating excess body temperature.

RECOMMENDATION

It is possible to face thermal stress and reduce its negative effects in many ways, including increase the proportion of amino acids or the amount of vitamin E and C in feed or drinking water, where it was found that giving these vitamins to animals contribute to reduce the negative effects of thermal stress as activates secretion of adrenal gland hormones that play an important role to provide the body with the necessary energy to reduce the effects of heat stress and also activate the immune system in addition to its resistance to the oxidative effect caused by fungal toxins. Niacin (nicotinic acid) can also be given or added to electrolytes such as sodium carbonate, potassium chloride and ammonium chloride in feed.

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CONFLICT OF INTEREST

This research is a personal non-profit work and there is no conflict of interest.

AUTHORS CONTRIBUTION

All of authors Alyaa S. K. Al-Shammari, Ali D. M. Al-Hashimi, and Ali H. M. H. Rabeeaare were responsible for surgical operation and samples collection.

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