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CLINICAL,HEMATOLOGICAL, BIOCHEMICAL, ARTERIAL BLOOD GAS ANALYSIS AND ACID BASE CHANGES ASSOCIATED WITH HYPO-VENTILATION AND RESPIRATORY DISEASES IN GERMAN SHEPHERD DOGS.

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SUMMARY

A total number of 40 male German Shepherd dogs less than 3 - years age were used in this study. Ten of them were apparently healthy and used as a control group (group I), 10 of them were sampled just after performing an exercise (400-meter race) served as fitness group (group II), 10 of them were examined after transportation for one hour in crowded van at hot weather (42°C) and direct sun light (group III), and 10 were diseased with different respiratory diseases (2 tonsillitis , 4 bronchopneumonia, 4 pneumonia) (group IV). Blood and serum samples were collected from each animal in all groups for hematological and biochemical examination. In addition, heparinized blood samples were collected from the femoral artery from each animal for determination of acid- base status, and blood gas analysis.

Results revealed significant increase in the respiratory rate in both groups (II), (p> 0.05) and IV (p > 0.01) groups, and in pulse rate in group IV (p> 0.01) . The erythrogram showed significant increase in hemoglobin (HB), hematocrit (PCV) and RBCs count in both groups (II) and (III) (P>0.05).

The leukogram showed significant increase in WBCs and neutrophils counts in groups (II) (P> 0.05) and (IV) (P>0.01) with significant decrease (P> 0.05) in lymphocytes. Significant decrease of blood pH was noted in groups (III) and (IV) (P>0.001), significant increase in PaO2 in groups (III) and (IV) (P < 0.01), decrease in PaCO2 in groups (III) (p>0.01) and (IV) (P>0.05), significant increase in A-a gradient in groups III and IV (P>0.01), significant increase of bicarbonate in group IV (P> 0.01) in comparison to the control group (I). Serum sodium showed significant increase in groups II and III (P>0.001); and significant decrease in group IV (P>0.01). Serum potas-

sium revealed significant increase in group II, III ($P>0.001$) and IV ($P>0.01$).

INTRODUCTION

German Shepherd and Labrador Retriever dogs were used in army and police services . Training and racing are important for fitness of the dogs. Training result in certain physiological and biochemical adaptations in sled dogs, So, energy and water requirements increase dramatically (Hinchcliff, 1995) . Increases in measurements of PCV values and RBC counts at rest are indicative of enhanced oxygen transport, which is necessary during the peaks of training periods (Konrad et al., 1990, Querengaesser et al., 1994 Kronfeld at al., 1997). Sodium and potassium fell in the first month of training, then rose to maximum levels in the second month, followed by a decline to normal values in the third month. Fit dogs have lower heart rates and rectal temperatures than unfit dogs (Sneddon et al. 1989, Burr et al., 1997). Moreover, training improves the mechanisms of adaptation in dogs (Combrisson and Bolnot, 1990).

Blood gas analysis is a sensitive indicator for changes in lung function and pathology but mild respiratory diseases usually show unaffected blood gas parameters (DiBartola and De Morais,1992, Abou El-Enean and Abd EL- Raof , 1999). Blood gas analysis is also useful in diagnosis and determination of the appropriate therapy for specific and complex conditions (Proulx, 1999). The aim of blood gas analysis is to assess partial pressure of oxygen in arterial blood (PaO_2) and partial pressure of carbon dioxide in arterial blood ($PaCO_2$) to determine the degree of hypoxia or hypercapnia . Normal partial arterial pressure of oxygen is 90 to 100 mmHg, values less than 60 mmHg indicates significant hypoxia. When PaO_2 drops below 40 to 50 mmHg, cyanosis develops. The normal $PaCO_2$ is 35 to 45 mmHg, hypercapania is present at $PaCO_2$ value greater than 60 mmHg, resulting in respiratory acidosis (Hawkins, 1998 , Corcoran, 2000).

The major respiratory abnormalities affecting gas tension includes hypoventilation and ventilation-perfusion mismatch (V/Q). Hypoventilation occurs due to upper air-way obstruction, pulmonary diseases, pleural effusion, pneumothorax, extreme abdominal distention, and decreased respiratory muscles functions. V/Q typically is associated with significant lower airway and lung parenchyma disease (Hawkins, 1998 , Corcoran 2000). Blood gas analysis also allows differentiation of alveolar hypoventilation from V/Q by calculation of alveolar (A) arterial (a) oxygen gradient (A-a). The normal A-a is less than 10 mm Hg, in hypoventilation it is less than 15 mm Hg, while in V/Q it is more than 15-20 mmHg. (Corcoran, 2000).

Retention of CO_2 as a result of hypoventilation results in respiratory acidosis. If the problem persists for several days, compensatory retention of bicarbonate by the kidneys occurs (compensatory metabolic alkalosis). Excess removal of CO_2 by the lungs caused by hyperventilation results in respiratory alkalosis (Hawkins ,1998, Abou El-Enean and Abd EL-Raof , 1999).

The aim of this study is to present the effect of fitness, hypoventilation in hot weather and respiratory diseases on respiratory and pulse rates , rectal temperature, erythrogram, leukogram , blood gases and acid - base status , and serum sodium and potassium in German Shepherd dogs.

MATERIAL AND METHODS

Animals : A total number of 40 male German Shepherd dogs less than three years of age were examined. Ten of them were apparently healthy and were used as a control group (I), 10 apparently healthy dogs were examined just after finishing their exercise (400 meters race) fitness group (II), 10 apparently healthy were examined after transportation in a van at hot weather (42°C) , direct sun light and crowdress for one hour, hypoventilation group (III)) , and 10 diseased dogs with different upper and lower respiratory tract affections (IV). These animals were examined during the period from May to September, 2002.

Samples:

A) Venous blood for hematological and serum samples : Venous whole blood samples were collected from each dog in the control and tested groups. The venous blood samples were collected from the medial saphenous vein according to Smith (1999) on EDTA and used for hemogram estimation, second part of blood was taken without anticoagulant for serum separation and used for sodium and potassium determination using Jenway flame photometer, England. (Mamdouh, 1986). Blood cell counter ABC counter, France was used for determination of RBCs , PCV, HB, MCV, MCH, MCHC and WBCs counts. Stained blood films with Leishman stain were prepared for differential leukocytes count (DLC).

B) Arterial blood samples: Arterial blood samples were collected from each dog of the control and tested groups, from the femoral artery according to Smith (1999). These blood samples were collected anaerobically on sodium heparin and used for determination of acid-base parameters and blood gases by Chorion 238 pH blood gas analyzer at 37°C according to Corcoran (2000). These arterial blood samples were transferred on ice, to be analyzed in not more than half an hour of collection. The alveolar (A) to arterial (a) gradient (A-a) was calculated by the equation $A\text{-}a = (150 - (PaCO_2 / 0.8) - PaO_2$ according to Corcoran (2000).

Statistical analysis : Statistical package for social sciences (SPSS) computer program was used for data analysis (Motulsky, 1999).

RESULTS AND DISCUSSION

Clinical findings :

The clinical findings of control and tested groups were summarized in table 1. Clinical diagnosis of the group of German Sphepherd with respiratory diseases were tonsillitis (2), bronchopneumonia (4) and pneumonia (4).

The respiratory rate , pulse rate and temperature of control and tested groups of German Sphepherd dogs were presented in table 2. Significant increase of respiratory rate was observed in fitness and hypoventilation groups ($p<0.05$) and in respiratory diseased group ($p < 0.01$) in comparison with the control group. There was significant increase of the pulse rate in the respiratory diseased group ($p<0.01$) in comparison to the control group. No changes in pulse rate and rectal temperature were reported in fitness, hypoventilation and respiratory diseased groups. Ilkiw et al ., (1989), Matwichuk at al., (1999) and Abdel Maksoud (2002) reported similar results in Labrador retrievers dogs after strenuous exercise and in German Shepherd dogs after fitness, hypoventilation and respiratory disease. It has been reported that rectal temperature increases in fitness because a portion of nutrient energy is converted to heat during cellular metabolism (Matwichuk et al., 1999). Possible explanations for the increased respiratory rate associated with fitness include response to increased O2 demand, in response to increased body temperature, concurrent transmission of neurological impulses to contracting muscles and respiratory centers, and stimulation of respiratory center by neurological impulses from joint proprioceptors (Musch et al., 1986).

Regarding the erythrogram of control and tested groups of German Shepherd dogs (table 3) , there was significant increase of hemoglobin (HB), hematocrit (PCV) and RBCs count in the fitness group ($p>0.01$), and hypoventilation group ($p>0.05$). Insignificant changes in HB, PCV and RBCs were recorded in the respiratory diseased group. Values of MCV, MCH and MCHC in all groups did not change in comparison to the control group. The observed significant increase of HB and PCV was regarded to increases in number of RBCs rather than volume as while there was no significant changes in MCV, MCH and MCHC. Moreover, there was slight decrease in body fluids during racing which leads to hemoconcentration and significant increase of HB, PCV and RBCs. Similar results were previously reported by Ilkiw et al. (1989), Nold et al. (1991), Toll et al. (1995), and Jain (2000) in racing Greyhound dogs after 704 meters race , Matwichuk et al. (1999) Similarly reported in Labrador retriever dogs after 10 minutes exercise and Abdel-

Table (1) Summary of the clinical findings of control, fitness, hypoventillated and respiratory diseased German Sphepherd dogs

Variables	Control (I)		Fitness (II)		Hypoventilation (III)		Respiratory Diseased (IV)	
	Number	%	Number	%	Number	%	Number	%
Nasal discharges								
Normal serous	8	80	9	90	10	100	5	50
Seromucoid	2	20	1	10	0	0	1	10
Muco-purulent	0	0	0	0	0	0	3	30
Purulent	0	0	0	0	0	0	1	10
Cough								
Normal	10	100	10	100	10	100	3	30
Mild cough	0	0	0	0	0	0	6	60
Severe cough	0	0	0	0	0	0	1	10
Dyspnea								
Normal	10	100	10	100	6	60	4	40
Dyspnoeic	0	0	0	0	4	40	6	60
Tonsillitis								
Normal	10	100	10	100	10	100	8	80
Mild	0	0	0	0	0	0	1	10
Severe	0	0	0	0	0	0	1	10
Chest wheezes (dry rales)								
Normal	10	100	10	100	10	100	1	10
Mild	0	0	0	0	0	0	5	50
Severe	0	0	0	0	0	0	4	40
Chest crackles (moist rales)								
Normal	10	100	10	100	10	100	1	10
Mild	0	0	0	0	0	0	5	50
Severe	0	0	0	0	0	0	4	40
Chest crepitations								
Normal	10	100	10	100	10	100	4	40
Moderate	0	0	0	0	0	0	3	30
Severe	0	0	0	0	0	0	3	3

Maksoud (2002) in German Shepherd and Labrador retrievers dogs after 400 - meters race. On the other hand, significant decrease of HB, PCV and RBCs was reported by Burr et al. (1997) in sled dogs after long - distance races (1.100 -mile race) and Hinchcliff et al., (1997) in Alaskan sled dogs after a 3.00-mile race which was consistent with an increase in plasma volume. Exercise training was recoded to increase plasma volume in Greyhounds dogs , horses and human beings (Mckeever et al., 1985 and Mckeever et al., 1987).

Leukogram of control and tested groups of German Sphepherd dogs (table 3), showed significant increase in WBCs in the fitness group ($p<0.05$), in comparison to the control group. Hypoventilation group revealed significant increase in monocyte and decrease in lymphocytes. ($p>0.05$). Matwichuk et al., (1999) and Jain (2000) stated that immediately after exercise, there is significant increase in both WBCs (physiological leukocytosis) due to neutrophilia and respiratory diseased group showed marked leukocytosis with increased number of neutrophils , monocytes, and lymphocytes. The occurred changes was mainly due to the presence of bacterial infections (tonsillitis , bronchopneumonia and pneumonia) which induce such elevation as discussed by Ilkiw etal., (1989), Jain (2000) and Abdel-Maksoud (2002)

The arterial blood gas analysis is reported in table 4. Statistical analysis showed significant decrease in pH and PaO2 in the hypoventilation group and respiratory disease ($p<0.001$), in comparison to the control. Partial arterial pressure of carbon dioxide (PaCO2) and alveolar to arterial gradient (A-a) revealed significant increase in the hypoventilation and the respiratory diseased groups. Bicarbonate values showed significant increase in the respiratory diseased group only. The base excess (BE) showed significant decrease in the hy-

Table (2) Respiratory rate , pulse rate and temperature of control, fitness, hypoventilation and respiratory diseased German Sphephred dogs (mean values ± standard errors).

Parameters	Control (I)	Fitness (II)	Hypoventilation (III)	Respiratory Diseased (IV)
Respiratory rate (breaths/min)	16.8±1.32	23.65±2.18*	22.35±1.81*	39.0±4.5**
Pulse rate (bearts/min)	88.55±3.76	95.2±6.17	96.7±4.0	135.4±3.53**
Temperature (°C)	38.1±0.23	39.0±0.35	39.0±0.35	39.4±0.34

* Significant at P<0.05 ** Significant at P<0.01

Table (3) Blood picture of control, fitness, hypoventilation and respiratory diseased in German Sphepherd dogs (mean values ± standard errors)

Parameters	Control (I)	Fitness (II)	Hypoventilation (III)	Respiratory Diseased (IV)
Hemoglobin (g/dl)	15.96±0.63	21.76±0.85**	17.25±0.55*	15.97±0.73
Hematocrite (%)	45.58±1.62	62.16±2.12**	48.96±1.42*	45.52±2.04
RBCs ($X10^6/\mu l$)	6.40±0.26	4.896±0.19**	6.88±0.19*	6.42±0.32
MCV (fl)	71.2±0.84	70.98±0.54	71.2±0.45	70.9±0.96
MCH (pg)	24.87±0.29	24.93±0.18	24.9±0.15	24.88±0.18
MCHC (g/dl)	35.04±0.50	35.03±0.38	35.26±0.38	35.07±0.08
WBCs ($X10^3/\mu l$)	6.68±0.53	8.03±0.20*	6.68±0.53	12.25±0.08**
Neutrophil ($X10^3/\mu l$)	3.55±1.62	4.59±2.07	3.68±1.62	6.186±0.53*
Lymphocyte ($X10^3/\mu l$)	2.41±1.37	2.56±1.70*	2.004±1.59*	3.89±0.67*
Basophil ($X10^3/\mu l$)	0.022±0.34	0.070±0.39	0.044±0.32	0.010±0.21
Eosinophil ($X10^3/\mu l$)	0.296±0.57	0.436±0.61	0.242±0.66	0.70±0.26
Monocyte ($X10^3/\mu l$)	0.265±0.59	0.359±0.62	0.71±0.48*	1.45±0.34**

* Significant at P<0.05 ** Significant at P<0.01

poventilation and the respiratory diseased groups (p<0.01).

The results of arterial blood gas analysis of the fitness group in our study differ from those reported by Toll at al. (1995) and Matwichuk et al. (1999) who mentioned that immediately after fitness, the arterial blood pH and PaO2 and bicarbonate concentration were significantly decreased. The result of the German Shepherd dogs exposed to hypoventilation and hot weather in our study were similar to Corcoran (2000) who stated that the stress of hypoventilation may suggest the decline in arterial PaO2 and pH and the elevation of PaCO2 and bicarbonate concentration with alveolar to arterial gradient (A-a) from 10-15 mmHg which indicates hypoventilation (Hawkins , 1998). Arterial blood gas analysis of the respiratory dis-

Table (4) Arterial blood gases and serum electrolytes of control , fitness , hypoventilation and respiratory diseased in German Sphepherd dogs (mean values ± standard errors).

Parameters	Control (I)	Fitness (II)	Hypoventilation (III)	Respiratory Diseased (IV)
pH	7.41±0.02	7.42±0.01	7.33±0.01***	7.37±0.03***
PaO2 (mmHg)	94.5±1.47	100.6±3.38	63.45±2.67**	59.3±23.71**
PaCO2 (mmHg)	37.9±1.33	33.5±3.38	58.8±2.12**	43.8±2.15*
A-a (mmHg)	8.13±0.77	7.49±1.62	13.04±1.55**	35.95±2.30**
Bicarbonate (mEq/liter)	19.06±0.17	19.0±0.15	21.79±0.3	23.0±0.75*
Base execss (mEq/liter)	3.3±0.13	3.18±0.07	2.67±0.15**	2.65±0.75**
Sodium (mEq/liter)	149.6±2.35	167.0±2.16***	159.5±1.31***	141.2±0.63**
Potassium (mEq/liter)	4.05±0.15	5.68±0.16***	4.96±0.13***	4.53±0.07**

* Significant at P<0.05 ** Significant at P<0.01 *** Significant at P<0.01

eased group is similar to those reported by Parent at al. (1996) in dogs with acute respiratory distress syndrome, Corcoran et al. (1999) in West Highland White terrier dogs with chronic pulmonary disease and Abdel Maksoud (2002) in German Shepherd and Labrador retrievers dogs who reported highly significant decrease in pH, PaO2 and base excess with highly significant increase in PaCO2 , A-a >15 mmHg (indicates V/Q mismatch) and bicarbonate . Elevation of A-a value occurs in diseases causing diffusion impairment which may be explain PaO2 decline and PaCO2 and bicarbonate elevation in the respiratory disease group (Hawkins, 1998).

The serum levels of sodium and potassium are presented in table 4. There was significant increase in sodium in the fitness group (P<0.01) , and hypoventilation group (P<0.001) , While , significant decrease was reported in the respiratory disease group (P<0.01). The results of serum potassium revealed significant increase of potassium level in fitness group (P<0.001), hypoventilation group (P<0.001) and in the respiratory diseased group (P<0.01) in comparison with the control. Ilkiw et al. (1989), Toll et al. (1995), Matwichuk et al. (1999) and Abdel- Maksoud (2002) reported similar results in short distance race. On the other hand, Burr et al., (1997) reported slight significant decrease in serum sodium and potassium in response to exercise (1.100-mile and 3.00- mile races , respectively) in sled dogs . Moreover, Hinchcliff et al. (1993) reported non significant increase of serum sodium and significant decrease (P<0.05) of serum potassium in sled dogs after 575- mile long race . They added that because no signs consistent with hypokalemia , such as muscle weakness or fasciculation, were observed, this decrease was not considered clinically important.

It can be concluded that significant changes were reported in respiratory and pulse rates, hemogram, arterial blood gases, acid base balance and serum electrolytes in German Shepherd dogs subjected to fitness, hypoventilation or different respiratory affections.

REFERENCES

Abdel Maksoud, E.M. (2002) : A study on respiratory functions in dogs under some sterss factors and respiratory affections. M.Vet. Sci. Thesis, Faculty of Vet . Med., Cairo university.

Abou el-Enean, G.E and Abd-El-Raof, Y.M. (1999): Arterial blood gases, acid base and serum electrolytes in diabetic dogs with chronic renal failure. Banha Vet.Med.J., 10(2): 52-61.

Burr, J.R., Reinhart, G.A. Swensen, S.S, Vaughn, D.D. , Bradley, D.M. (1997): Serum biochemical values in sled dogs before and after competing in long-distance races. JAVMA, 211(2): 175-179.

Coles, E.H. (1986): Veterinary clinical pathology. 3rd ed., W.B. Saunders company, Pheladelphia. 340-347.

Combrisson, H., Bolnot, D. (1990): Cardiovascular and respiratory adaptations to muscular effort in dogs. Recueil de . Medecine Veterinaire, 166(4) : 391- 398.

Corcoran , B. (2000): Clinical evaluation of the patient with respiratory disease . In Ettinger , S.J. (ed) and Feldman , E.C. (2000) : Text book of veterinary internal Medicine, diseases of dog and cats, 5th edition. 1034- 1039.

Corcoran, B.M., Cobb, M., Martin , M.W.S., Dukes- McEwan, J., French, A., Luis Fuentes, V., Boswood, A., Rhind, S. (1999) : Chronic pulmonary disease in West Highland white terries. Veterinary record, 144:611-616.

Di Bartola, S.P., De Morais, H.S.A. (1992) Respiratory acid - base disorders. In Di Bartola, S.P.(ed): Fluid therapy in small animal practice. Philadelphia, W. B. Saunders, 258

Ettinger, S.J.(2000): Coughing. In Ettinger, S.J.and Feld-Man, E.C.(2000): Text book of veterinary internal medicine, diseases of dog and cats, 5thedition, 162-166.

Hawkins, E.C. (1998): Respiratory disorders. In Nelson, R.W. (ed) and Couto, C.G (ed) (1998): Small animal internal medicine , Mosby, London, 205-344.

Hinchcliff, K.W. (1995) : Energy and water expenditure. In proceedings. Perform dog Nutr. Symp. 4-9.

Hinchcliff, K.W. , Olson, J., Crusberg, C. Kenyon, J., Long, R., Royle, W., Weber, W, Burr, J.(1993) : Serum biochemical changes in dogs competing in a long - distance chemical changes in dogs competing in a long - distance sled race . JAVMA,202(3): 401- 405.

Hinchcliff, K.W. , Reinhart, G.A., Burr,J.R., Schreier, C.J., Swensen, R.A. (1997) : Effect of racing on serum sodium ñ and potassium concentrations and acid- base status of Alaskan sled dogs. JAVM. A, 210(11) : 1615-1618.

Ilkiw, J.E. Davis, P.E., Cherch, D. B. (1989) : Hematologic, biochemical, blood-gas , and acid base values in greyhounds before and fitness. AJVR, 50(4) : 583 -586.

Jain, N.C. (2000): Schalm's Veterinary Haematology. 5th Ed., Lea and Febiger, Philadelphia, USA..

Konrd, J. Cupak, M, Hrusovsky, J., Husak, S., Smnid, K. (1990) : Mineral metabolism in dog during training and stress of work . Veterinari- Medicina , 35(7) : 427- 435.

Kronfeld, D. S.; Hammel, E.; Ramberg, C.F.J (1997): Hematological and metabolic responses to training in racing sled dogs fed diets containing medium, low or zero carbohydrate. Am.J. Clin. Nutr., 30: 419-430.

Mamdouh, E. (1986) : Studies on acid - base balance and electrolyte balance. M.V.Sc. Thesis , Assiut umei.

Matwichuk, C.L., Taylor, S.M., Shannon, C.L., Kass, P.H., Shelton, G.D.(1999): Changes in rectal temperature and hematological, biochemical, blood gas acid - base values in healthy Labrador Retrievers before and after strenuous exercise. AJVR, 60(1) : 88-92.

Mckeever, K.H., Schurg, W.A., Convertiso, V.A.(1985): Exercise. training- induced hyporvolemia in Greyhounds: role of water intake and renal mechanisms. J. Appl. Physiol., 248-425.

Mckeever, K., Schrug, W, Jarrett, S.(1987): Exercise training - induced hypervolemia in the horse . Med. Sci. Sports exerc., 19:21- 27.

Motulsky, H.J. (1999): Analyzing Data with Graph Pad Prism, Graph Pad software, San Deigo, USA.

Musch, T.I., Friedman, D.B., Haidet, G.C. (1986): Arterial Blood gases and acid base status of dogs during graded dynamic exercise. J.Appl. Physiol., 61: 1914 - 1919.

Nold, J.L.; Peterson, L.J. and Fedde, M.R. (1991): Physiological changes in running greyhound (Canis domesticus) : Influence of race length. Comparative Biochemistry and Physiology. A- comparative physiology, 100(3) : 623- 627.

Parent, C.; King, L.G., Van Winkle, T.J., Walker, L.M. (1996) : Respiratory function and treatment in dogs with acute respiratory distress syndrome: 19 cases (1985 - 1993) . JAVMA, 208(9) : 1428- 1433.

Proulx, J.(1999): Respiratory monitoring : arterial blood gas analysis , pulse oximetry , and end -tidal carbon dioxide analysis . Clin. Tech. Small. Asim . Pract., 14(4) : 227-230.

Quernsgaesser, A., Iben, C., Leibetseder, J. (1994): Blood changes during training and racing in sled dogs. J. Nutr., 124 : 27605 - 27645.

Smith, B.J. (1999): Canine anatomy . In the national veterinary medical series for independent study.

Sneddon, J.C.Minnaar, P.P., Grosskopf, J.F.W. groenevelde, H.T. (1989): Physiological and blood biochemical responses to sub maximal treadmill exercise in canoan dogs , before , during and after training. J.of the South African Veterinary Sciencce, 60 (2) : 87 - 91 .

Tool, P.W., Gaehtgers , P., Neuhaus, D., Pieschl, R.L., Fedde, M.R. (1995): Fluid, electrolyte, and packed cell volume shifts in racing greyhounds . Am J.Vet. Res . 56 (2) : 227 - 232.