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SOME BIOCHEMICAL STUDIES ON BLOOD OF RACING CAMELS

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SUMMARY

The aim of this study was to clarify the normal values and the changes of hemogram, some biochemical parameters, and some hormones in both athletic and non-athletic camels. The racing tests were carried out in El-Arish, Egypt, on twenty-seven apparently clinically healthy athletic and non- athletic camels. Blood samples were collected aseptically from jugular vein before and after 6-km camel race competition. The results showed a significant increase in red cell counts, hemoglobin concentration, hematocrite value in both athletics and non-athletic camels after 6-km racing, while the derived red cell indices remained without significant changes. Serum concentration of K^+ increased significantly in post racing athletics and non- /athletic camels, while Na^+ increased significantly in non- /athletic camels only. HCO_3- and Ca^{2+} decreased significantly while chloride remained without significant changes in both athletic and non-athletic camels. In contrast to other athletic animal species, the serum glucose concentration increased significantly in the post-racing camels. Similarly, there was significant increase in blood lactate, total protein, albumin and globulin in both athletics and non- athletic camels. Non-esterfied fatty acids increased significantly in athletic camels while it decreased significantly in non- /athletic camels. Furthermore, both serum cortisol and urine vainylmandelic acid increased significantly in post racing camels.

In conclusion, racing camels showed hematological, electrolyte, and metabolic responses to such race similar to those reported in other animal species except that of glucose. On comparison between the athletic and non-athletic camels, the most interesting observations recorded in this study were: (1) the high increase in plasma Na^+ concentration in non-athletic camels versus no changes in athletic camels; (2) the highly significant decrease in calculated strong ion difference

in non-athletic camels versus no change in athletic camels; and (3) while non-esterfied fatty acids decreased significantly in non- /athletic camels, they increased in athletic camels.

INTRODUCTION

Camel is described as the ship of the desert as it was used to transport goods across the deserts of Arabia and Asia. It was well known for its feats of endurance, being able to travel at 16 km/h for up to 18 h, less is known about its ability to travel at faster speeds, i.e. the pace and gallop, for relatively long periods. Within Arabic countries, the camel traditional use has been supplanted by motorized transport. However, its cultural importance has been maintained by the introduction of camel racing. Although the physiological adaptations of the camel have been studied extensively, biochemical changes associated with exercise were ignored until recently. The desire to breed and train faster camels has led to research projects along the lines of those used to improve the human and equine athlete (Werney and Kaaden, 1995).

The increase in endurance riding allover the world has brought many veterinarians into contact with this equestrian discipline. An endurance ride is a competition to test the speed and endurance ability of an animal. In traditional training of racing camel, exercise over distances of 15-20 Km per day at speeds varying from 2-6 m s^{-1} is typical, while competition-racing distances are usually between 4-10 Km at speeds up to 11-12 ms^{-1}. The wide ranges of speeds and distances of which camels are capable raise interesting questions relating to their metabolic capacity (Rose et al., 1994). The racing camel is required to perform high intensity exercise, particularly at the beginning and at the end of traditional races, which are held over distances varying from 4-10 Km (Knight et al., 1994b). Exercise is associated with changes in acid-base status. Exercising horses often show a tendency to both metabolic acidosis, due to accumulation of lactate, and respiratory alkalosis, as a consequence of hyperventilation. Moreover, changes in plasma water content and modification of the ionic composition of blood are also associated with exercise (Tejero et al., 2000). However, camels showed metabolic responses to such exercise, similar to those reported in other species (Knight et al., 1992). Clearly therefore, the main aim of the current study was to clarify the effect of camel racing on some biochemical parameters in athletic and non-athletic camels. The main studied biochemical parameters include the following: I) Plasma electrolytes (Na^+, K^+, Cl^- and HCO_3^-) and serum Ca^{2+} ; II) Some plasma substrates (lactate, glucose, non-esterfied fatty acids, triaclglycerol, total protein and albumin); III) Anion gap (AG) and strong ion difference (SID) were calculated as indices for determining the acid-base status. IV) Some serum enzymes (transaminases, creatine phosphokinase and lactate dehydrogenase); and V) Serum corti-

sol levels and urine concentration of 3-methoxy-4-hydroxy vanillylmandelic acid, which represents the O-methylated deaminated product of catecholamines.

MATERIALS AND METHODS

The current study was carried out on a total number of 27 apparently clinically healthy trained and untrained male camels. All animals were 3-6 years old and had body weight of 320-450 kg. Before the beginning of the race test, the untrained animals were well accustomed to perform a race. In the present study, the animals were required to perform a race, which was held over a distance of 6-km. Camel racing and blood samples collection was performed during April in El-Arish, Egypt.

Blood Sampling: Blood samples were collected aseptically from jugular vein before and after camel racing, then blood samples were divided into four aliquots as following:

1. One aliquot was collected on EDTA for hemogram analysis that included: red blood cells (RBCs), hemoglobin (Hb), packed cell volume (PCV), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC).
2. The second aliquot was collected on heparin for determining the concentration of lactate and electrolytes, which included sodium (Na^+), potassium (K^+), chloride (Cl^-) and bicarbonate (HCO_3^-).
3. The third aliquot was collected on sodium floride for glucose determination.
4. The fourth aliquot was left to clot and the obtained sera were used for the determining the concentration of calcium (Ca^{2+}), non-esterfied fatty acids (NEFA), triacylglycerols (TG), cortisol hormone and some enzymes including aspartate aminotransferase (AST), alanine aminotransferase (ALT), creatine phosphokinase (CPK), and lactate dehydrogenase (LDH).

In addition, about 50 ml of urine samples were collected from camels before and after racing for the measurement of 3-methoxy-4-hydroxy mandelic acid (Vanillyl mandelic acid, VMA). All plasma, sera, and urine samples were kept at –20°C till the time of analysis, while hemogram analysis was performed on the same day of blood collection. RBCs number, PCV, and Hb concentrations were determined according to Miller and Seward (1971), Wintrobe (1967) and International Committee for Standardization Hematology (1967), respectively. Blood indices (MCV, MCH, and MCHC) were calculated by standard formula according to Dacie and Lewis (1977). Electrolytes including Na^+, K^+ and Cl^- were determined biochemically according to Henry et al. (1974) for both Na^+ and K^+, and Feldkamp et al. (1974) for Cl^-. HCO_3^- concentration was determined using Blood Gas Analyzer according to West

(1990). Anion Gap (AG) was calculated according to the equation of Emmet and Narins (1977): $AG=[Na^+ + K^+]- [Cl^- + HCO_3^-]$. Lactate and Ca^{2+} concentrations were determined colorimetrically according to Neville and Gelder (1971) and Gindler et al (1972), orderly. Strong Ion Difference (SID) was calculated following the equation recorded by Figge et al (1992): $SID = [Na^+ K^+ + Ca^{2+}] - [Cl^- + lactate]$. The concentration of glucose, NEFA and TG were determined colorimetrically orderly according to Trinder (1969), Duncombe (1964) and Annoni et al (1982). Serum enzyme concentrations including transaminases (AST and ALT), CPK and LDH were determined kinetically according to Reitman and Frankel (1957), Gruber (1978) and Varley et al (1980), respectively. Cortisol levels were measured by radioimmunoassay (RIA) technique using active RIA cortisol kit (DSL, Webster, Texas, USA) according to Schlaghecke et al. (1992). The intra and interassay coefficient of variation were 8.2% and 9.4%, respectively. The urine concentrations of VMA were measured biochemically according to Pisano et al (1962). All results were statistically analyzed according to Kirkwood (1989)

RESULTS AND DISCUSSION

As shown in table (1) of the present study, it has been observed that, while there was a significant increase in the concentrations of K^+ (68.4%), there was a significant decrease in HCO_3^- concentration (11%) in the plasma of the post-racing athletic camels. Both Na^+ and Cl^- concentrations remained without significant changes. Furthermore, AG revealed a significant increase of 2.66 fold. On the other hand, in non-athletic camels, both Na^+ and K^+ revealed a significant increase representing respectively 14.4% and 82%, while HCO_3^- showed a significant decrease of 20.9%. The increase in both Na+ and K^+ and the decrease in HCO_3^- led to an increase of 3.87 fold in the calculated AG. The effect of exercise on plasma electrolyte values has been evaluated in several studies and the obtained findings are similar to our results. Knight et al (1994b) and Hamada and El-Badry (2002) found that, during high-intensity exercise, there was an increase in both sodium and potassium in the racing camels accompanied by a non-change (with a tendency to a decrease) in chloride. The increase in plasma sodium concentration detected after camel racing could be explained by the loss of plasma water; the elevation in albumin (26% and 33% in athletic and non-athletic camels, respectively) supported this explanation and was similar to that reported in the racing horses (Tejero et al., 2000). However, Na^+ concentration after racing, especially in athletic camels, was less than what would be expected from the increase in albumin. The difference between serum increases in Na^+ and albumin might be related to loss of Na^+ in sweat (McCutcheon et al., 1995). The increase in plasma K^+ concentration after camel racing could be attributed to the shift of K^+ ions from intra- to extracellular

Table 1: Plasma concentration of electrolytes and lactates, serum concentration of Ca^{2+}, and the calculated values of AG and SID in athletic and non-athletic camels before and after 6-km racing.

	Athletic Camels		Non-athletic Camels	
	Pre-race	Post-race	Pre-race	Post-race
Na^+ (mmol/L)	144±2.7	150±2.4	139±1.7	159±3.8*
Change %	+ 4.17		+ 14.4	
K^+ (mmol/L)	3.8±0.13	6.4±0.16**	3.9±0.13	7.1±0.29**
Change %	+ 68.4		+ 82.05	
Cl^- (mmol/L)	110.5±2.5	110.3±1.4	108±2.5	110.5±2.6
Change %	- 0.18		+2.3	
HCO_3^- (mmol/L)	27.9±0.77	24.8±1.07*	25.8±1.35	20.4±1.4*
Change %	- 11.11		-20.9	
AG	9.4±0.64	21.3±1.04**	9.1±1.3	35.2±1.5**
Change %	+ 2.66 fold		+ 3.87 fold	
Lactate (mmol/L)	2.4±0.14	10.2±0.14**	1.9±0.05	26.8±0.41**
Change %	+ 4.25 fold		+ 14.1 fold	
Ca^{2+} (mmol/L)	2.525±0.1	2.15±0.08*	2.475±0.85	1.88±0.04**
Change %	-15		- 24	
SID	37.4±0.42	38.05±0.31	35.48±0.64	30.68±1.8*
Change %	+0.39		- 13.5	

Means ± SE * significant at P<0.05 ** significant at P<0.01
(+) refers to increase (-) refers to decrease

compartment (Tejero et al., 2000). Moreover, the rise in K^+ might be due to its release from the contracting muscles fibers (Sjogaard, 1990) and it has also been proposed to be due to the inability of Na^+/K^+-pump not being able to match the outward flux of K^+ when action potential was propagated over the sarcolemma (Knight et al., 1992). Furthermore, the increase in Na^+ and/or K^+ with the decrease in HCO_3^- resulted in elevation of the AG (Hamada and El-Badry, 2002). Moreover, Tejero et al (2000) indicated that, during anaerobic exercise, the elevation in plasma lactate concentration could increase the AG.

Serum lactate in the present study showed an increase of 4 and 14-fold increases in both athletic

and non-athletic camels, respectively after the end of racing. This increase was concomitant high serum LDH concentrations (31% and 102%) in athletic and non-athletic camels, respectively. These results were in agreement with Knight et al (1994b) and Hamada and El-badry (2002). In addition, Tejero et al (2000) found an increase in plasma lactate concentration after show-jumpers exercise, reflecting the anaerobic metabolism of muscle cells. In human subjects exercising to fatigue, the degradation of glycogen to pyruvate and lactate was found to be involved in the generation of about 20% of the total used energy (Saltin et al., 1994). In addition, Snow et al (1988a) detected an increase in plasma lactate in camels after racing (21-24 mM/L). Whole blood lactate in the range of 15-30 mM/L has been reported in human subjects exercised to fatigue under similar circumstances (Medbo and Burgers, 1990). Furthermore, muscle lactate concentration approaching 100 mM/kg has been reported in other species (Bangsbo et al., 1990; Bangsbo et al., 1992 and Saltin et al., 1992). The higher lactate concentration that reported in the aforementioned studies, which exceeds the reported in the current study might be due to low intensity exercise used in their studies or to the short distance racing (about 4 km). Knight et al (1994b) found that after 2-4 km racing, the plasma lactate was consistently higher than after 8-10 km race in the same camels. Moreover, it has been reported that the decrease in plasma lactate concentration combined with a high proportion of LDH isoenzyme, could indicate an important role for lactate as a substrate during prolonged high intensity exercise in camel (Knight et al., 1994b). Nowdays, blood lactate have potential application in field studies of fitness (Davie and Evans, 2000).

In the present study, it has been observed that serum calcium concentration showed a significant decrease of about 15% and 24% respectively in both athletic and non-athletic camels. These results were in good agreement with Esmail et al (2002) who detected 35% decrease in serum calcium concentrations after highly intensive racing camels. Furthermore, these results are consistent with that reported in race-horses (Aguilera et al., 1998 and Aguilera et al., 2001). The authors attributed the decrease in serum calcium concentration to a decrease in plasma parathyroid hormone concentration in most racing horses.

The most interesting observation in the current study was the significant decrease in SID (15.4%) in non-athletic camels while there was non-significant changes in athletic camels. Exercise was found to be associated with changes in acid-base status. The decrease in SID in non-athletic camels might be due to lactic acidosis. Exercising horses often show a tendency to both metabolic acidosis, due to accumulation of lactate, and respiratory alkalosis, as a consequence of hyperventilation (Tejero et al., 2000). The slight increase in SID, in athletic camels, was due to the simultaneous increases in plasma Na^+ and K^+ concentra-

tion observed after exercise. Thus, according to Stewart (1983), changes in Na^+, K^+ and Cl^- concentrations contributed to the attenuation of the acidosis induced by the increase in lactate. The increase in Na^+ that could be caused by loss of plasma water represented an alkalotic trend leading to what is known as contraction alkalosis (Fencl and Rossing, 1989). Loss of intravascular water should be accompanied by a simultaneous increase in plasma Cl^- and not a decrease as found in the study of Tejero et al (2000). An increase in the SID, due to increased Na^+ and unchanged or decreased Cl^-, has been reported in exercising horses (Taylor et al., 1995 and Goetz et al., 1997).

The present study showed, respectively in athletic and non-athletic camels, a significant increase in serum concentration of glucose (31% and 50%) and cortisol 51% and 69%); and urine concentration of VMA (3.2-fold and 3.6-fold) after 6-km camel racing (Table 2 and 3). On the other hand, one of the most interesting observation was the increase in NEFAs in athletic camels (65%), while decreased in non-athletic camels (16.8%) as shown in table 2. These results were in agreement with the results of Evans et al (1994), since they demonstrated a significant increase in serum glucose, which increased further post-exercise to reach peak values after 10-min exercise. Moreover, Rose et al (1994) found a significant

Table 2: Plasma and serum concentration of some plasma substrates including glucose, NEFAs, TG, TP and albumin in athletic and non-athletic camels before and after 6-km racing.

	Athletic Camels		Non-athletic Camels	
	Pre-race	Post-race	Pre-race	Post-race
p Glucose (mg/dl)	113±5.1	148±4.5**	109±7.8	164±4.2**
Change %	+ 31		+ 50.5	
s NEFA (µmol/L)	337±17	558±14**	346±12	288±16*
Change %	+ 65.6		- 16.8	
s TG (mg/dl)	43±2.7	67±2.4**	39±1.6	75±5.1**
Change %	+ 55.8		+ 92.3	
sTP (g/dl)	6.6±0.21	8.0±0.25**	6.5±0.11	8.6±0.12**
Changes %	+21		+32	
s Albumin (g/dl)	3.4±0.15	4.3±0.23**	3.3±0.13	4.4±1.5**
Change %	+26		+33	

Means ± SE * significant at P<0.05 ** significant at P<0.01
(+) refers to increase, (-) refers to decrease, (p) refers plasma, (s) refers serum

Table 3: Serum levels of cortisol hormone and enzymes (AST, ALT, CPK, and LDH); and the urine concentration of VMA in athletic and non-athletic camels before and after 6-km racing.

	Athletic Camels		Non-athletic Camels	
	Pre-race	Post-race	Pre-race	Post-race
Cortisol (µg/ml)	3.7±0.9	5.6±1.2**	3.67±1.1	6.21±0.79**
Change %	+ 51.4		+ 51.4	
AST (U/ml)	57±3.5	79±4.2**	54±1.4	119±2.7**
Change %	+ 38.6		+ 120.4	
ALT (U/ml)	3.1±0.12	10.4±1.4**	6.7±0.76	24±0.73**
Change %	+ 3.4-fold		+ 3.6-fold	
CPK (U/ml)	213±11.4	218±11.2	188±4.5	249±4.3**
Change %	+ 2.3		+ 32.4	
LDH (U/ml)	297±13.3	390±27.5**	226±8.4	458±8.6**
Change %	+ 31.3		+ 102.6	
VMA (mg/L)	3.9±0.76	312.6±0.9**	3.82±0.73	13.9±0.6**
Change %	+ 3.2-fold		+ 3.6-fold	

Means ± SE ** significant at P<0.01 (+) refers to increase

increase in plasma glucose in individual camels with at least 4 animals doubling their glucose by the end of exercise. Furthermore, they found a high correlation between glucose and catecholamines, particularly noradrenaline, indicating that mobilization of liver glycogen reserves. Blood glucose has been found to be important as a substrate for red cell, kidney and brain metabolism and is obviously important to make up the shortfall in energy from the decreased rate of glycogenolysis in skeletal muscle which was evident during the last 30 min of camel exercise (Rose et al., 1994). Moreover, Elmahdi and Sallmann (1997) explained the high plasma glucose concentration in camels compared to sheep and ponies may be due to a poorer insulin response and/or reduced tissue sensitivity to insulin. Furthermore, the increase in serum cortisol levels in the post-racing camels may be partially explained by the postulation of Burgress et al., (1993) that highly trained athletes have increased corticotropic-releasing factor along with mild hypercortisolism. Moreover, in the earlier studies of Pritchard et al.; (1999), it was observed that short-term physical exercise could increase the serum cortisol levels. Furthermore, Hakkinen and Pakarinen (1993) showed that heavy resistance exercise caused acute endogenous cortisol responses that might

differ depending up on the type and/or the magnitude of stress of the exercise protocol utilized. However, Feitosa et al (2002) detected significant familial effects influencing levels of baseline cortisol and its response to training. Beaufort-Krol et al (2001) found a correlation between the rate of glucose production and the adrenaline concentration during exercise in lambs, suggesting that adrenaline played a part in the glucoregulation. Rose et al (1994) found that glucose concentration was coincident with the increase of catecholamines in the racing camels, indicating mobilization of liver glycogen reserves.

The increased post-racing serum concentrations of both NEFAs and triacylglycerols, in athletic camels, were in agreement with Rose et al (1994). The authors concluded that fat is relatively minor energy source during moderate intensity exercise and when carbohydrate stores were diminishing, not only there was enhanced fat combustion but also alternative energy sources were used such as branched chain amino acids. Beaufort-Krol et al (1999) and Beaufort-Krol et al (2001) found an increase in pyruvate, lactate and FFAs during lamb. It has been found an inverse relationship between the arterial FFAs concentration and the metabolic clearance of glucose in dogs (Bjorkman et al., 1988) and lambs (Beaufort-Krol et al., 2001). It has been concluded that glucose and FFAs are alternative fuels for the working muscles (Beaufort-Krol et al., 2001).

In contrast to the athletic camels, plasma FFAs concentration declined markedly after non-athletic camel racing. These results are in agreement with the findings reported by Snow et al (1988a). These findings suggested that, in the initial stages of exercise, circulating FFAs are used as a substrates; however as the exercise continues lipolysis in adipose tissue is unable to maintain the initial high concentrations, leading to a reduced availability of this substrate to working muscle (Snow et al., 1988a). Moreover, the reduction in plasma FFAs concentrations was probably a result of the inhibition of lipolysis by acidosis (Snow et al., 1988b).

In the present study, a significant increases in serum enzymes of AST, ALT, CPK and LDH were observed (Table 3), since the increases in these enzymes were approximately two-fold higher in non-athletic more than in athletic camels. Moreover, the non-athletic camels showed the symptoms of tiredness. Muscle soreness or tenderness in man and horses a few days after strenuous or unaccustomed exercise was reported to be paralleled to the rise in muscle enzymes in the blood. The extent of muscle damage can sometimes be estimated by the type and activity of enzyme in the serum (Art et al. 1990 and Beaunoyer, 1992). AST was found to be mostly bound to the mitochondria and, therefore, its elevation in the blood indicated serious cell damage. On the other hand, the absence of a significant increase in AST indicated that the exercise

test caused no severe muscle damage (Beaunoyer, 1992 and Cluer et al., 1994).

Examination of the changes in several enzymes patterns over a period of hours or days may reveal the time and extent of muscle cell damage. The activity levels of CPK, LDH and AST in the serum may indicate the effect upon muscle of the stressers associated with intense training or racing. Interpretation of elevated enzyme activities in the serum must be made with caution because these enzymes have sources other than muscles. Further, decreases in plasma volume during exercise due to fluid shifts may explain, in part, increases in serum enzymes activities without enzyme release. Additionally, an increase in muscle membrane permeability during exercise may cause a release of some intracellular enzymes into the circulation. Therefore, increases in serum enzyme activity immediately after strenuous exercise are not necessarily attributable to muscle cell disruption (Beaunoyer, 1992).

The findings in the present study for the MCV, MCH and MCHC (Table 4) were also in agreement with those previously obtained by Sarwar and Majeed (1997); Mohamed and Hussein (1999) and Hamada and El-Badry (2002). The

Table 4: Blood hemogram in athletic and non-athletic camels before and after 6-km racing

	Athletic Camels		Non-athletic Camels	
	Pre-race	Post-race	Pre-race	Post-race
RBCs (X 10^6/ mm^3)	7.9±0.22	10.2±0.4**	6.4±0.1	8±0.11**
Change %	+ 29.1		+ 25	
Hb (g/dl)	12.2±0.18	15.2±0.25**	10.3±0.09	13.5±0.12**
Change %	+ 24.6		+ 31	
PCV %	29.1±1.3	35.2±0.65**	22.4±0.55	26.9±0.53**
Change %	+ 21		+ 20.1	
MCV(*fl*)	37.3±0.89	37.7±1.4	34.3±0.82	33.7±0.87
Change %	+ 1.07		- 1.75	
MCH (*pg*)	15.4±0.4	15±0.66	16±0.18	16.4±0.25
Change %	- 2.6		+ 2.5	
MCHC (g/dl)	42.1±2	43.2±2.2	45.4±1.4	46.1±1.3
Change %	+ 2.6		+ 1.5	

Means ± SE ** significant at P<0.01 (+) refers to increase (-) refers to decrease

utmost important observation in the current study was the increase of 25%, 31%, 20% above pre-exercise values of RBCs, Hb and PCV in non-athletic camels, that was concurrent with increase of approximately four folds in AG. This suggested that hemoconcentration occurred during the period of racing. In addition, these changes were probably attributable to redistribution of body water and electrolytes from plasma to the interstitial or intracellular fluid compartment (Evans et al., 1992). Excitement prior to race may cause elevation of red blood indices. This factor can increase the PCV of the horse dramatically, as splenic contraction adds red cells to the general circulation (Knight et al., 1994a). The camel probably did not possess a large splenic reservoir of RBCs, but the results of Evans et al (1992) did not preclude the possibility of splenic contraction as a part of the exercise response in camels. Like horse, it was possible that a splenic contraction might have occurred prior to the commencement of exercise in the study of Snow et al. (1988a).

Camels therefore differ from horses and dogs, two other species selected for athletic activities, because in those two species exercise resulted in marked rise in PCV due to the release of RBCs stored in spleen (Snow and Harris, 1986). On the other hand, he camel is similar to man in that oxygen carrying capacity of the blood of camels and men are probably similar. Camel erythrocytes have a very high MCHC, which results in a hemoglobin content of the order of 155 g/L during exercise; Thus provided that oxygen combing capacity of camel hemoglobin is similar to that of man, i.e. 1.34 ml oxygen/g hemoglobin, the oxygen carrying capacity of their blood will also be similar (Snow et al., 1988a).

REFERENCES

Aguilera, E.; Estepa, G.C.; Lopez, I.; Pas, S.; Garfia, B. and Rodrigucz, M. (2001): Plasma ionized Ca2+ and parathyroid hormone concentration in horse after endurance rides. J. Am. Vet. Med. Assoc., 15, 219 (4): 488-490.

Aguilera, E.; Garfia, B.; Estepa, G.C.; Lopez, I.; May-Volor, R. and Rodriguez, M. (1998): Effect of exercise and EDTA administration on blood ionized Ca2+ and parathyroid hormone in horse. Am. J. Vet. Res., 59 (12): 1605-1607.

Annoni, G.; Bollasso, B.; Ciaci, D.;and Tripoli, A. (1982): Enzymatic determination of serum triglycerides. J. Res. Lab. Med., 9: 115.

Art, T.; Amory, H.; Desmecht, D. and Lekeux, P. (1990): Effects of show jumping on heart rate, blood lactate and other plasma values. Eq. Vet. J. 22. In Press.

Bangsbo, J.; Gollnick, D.; Graham, T.; Juel, C.; and Saltin, B. (1990): Anaerobic energy production and O2 defict-debt relationship during exhaustive exercise in human. J. Physiol, 422: 539-559.

Bangsbo, J.; Graham, T.; Kein, B.; and Saltin, B. (1992): Elevated muscle glycogen and anaerobic energy production during exhaustive exercise in man. J. Physiol., 415: 205-27.

Beaufort-Krol, G.C.M.; Takens, J.; et al. (1999): Lower arterial glucose concentrations in lambs with aortopulmonary shunts after an 18-hour fast. Metab., 48: 1082-1088.

Beaufort-Krol, G.C.M.; Takens, J.; Willem, G.; et al. (2001): Metabolic responses to moderate exercise in lambs with Aortopulmoanry shunts. Metab., Vol. 50 (4): 399-406.

Beaunoyer, D.E. (1992): Changes in serum enzyme activities after maximal exercise in camels. Proc. 1st Int. Camel Conf., 331-333.

Bjorkman, O.; Miles, P.; and Wasserman, D. (1988): Regulation of glucose turnover during exercise in pancreatectomized, totally insulin deficient dogs. Effects of β-adrenergic blockade. J. Clin Invest., 81: 1759-67.

Burgress, M. L.; Davis, M. J.; Borg, K. T.; Wilson, P. S.; Burgress, A. W. and Buggy, J. (1993): Exercise training alters cardiovascular and hormonal responses to intracranial self-stimulation. J. Appl. Physiol., 75 (2): 863-869.

Cluer D.; Henkel, P. and Saltin, B. (1994): Adaptations to training in the racing camel. Acta Physiol. Scand Supp., 617.

Dacie, J.V. and Lewis, S.M. (1977): Practical hematology, 5th ed. ELBS and Churchill Livingstone.

Davie, A.; and Evans, D. (2000): Blood lactate responses to submaximal field exercise tests in thoroughbred horses. The Vet J., 159: 252-58.

Duncombe, W.C. (1964): The calorimetric microdetermination of non-esterfied fatty acids in plasma. Clin Chem Acta, 9: 122-25.

EL Mahdi, B. and Sallmann, H. (1977): Comparative aspects of glucose tolerance in camel, sheep, and ponies. Comp. Biochem. Physiol., 118A (1): 147-51.

Emmet, M. and Narins, R. G. (1977): Clinical use of the anion gap. Medicine, 56: 38-54

Esmail, M.; Hamada, M.M.Z. and Moshera, M.E. (2002): Some biochemical alterations in highly intensive racing camel. 6thVet. Med. Zag. Conference (7-9 Sept.) Hurghada.

Evans, D. L.; Rose, R. J.; Knight, P. K.; Cluer, D. and Manefield, W. (1994): Some physiological responses to incremental treadmill exercise in the racing camel. Acta Physiol. Scand. Suppl., 617: 33-39

Evans, D.; Rose, R.; Knight, P.; and Mannefield, G. (1992): Physiological responses during an incremental treadmill exercise test in the camel. Proc. 1St Int Camel Conf.: 223-27.

Feitosa, M.F.; Rice, T.; Rosmond, R.; et al. (2002): A genetic study of cortisol measured before and after endurance training: the heritage family study. Metab., 51 (3): 360-365.

Feldkamp, C.S.; et al. (1974): Zkllin Chem Klin Biochem, 12: 146-150.

Fencl, V. and Rossing, T.H. (1989): Acid-base disorders in critical care medicine. Ann Rev Med, 40: 17-29.

Figge, J.; Mydosh, T. and Fencl, V. (1992): Serum proteins and acid-base equilibria: a follow-up. J Lab Clin Med, 120: 713-719.

Gindler, E.; et al. (1972): Colorimetric quantitative determination of calcium. Am. J. Clin. Path., 58: 376-86.

Goetz, T.E.; Manohar, M.; Griffin, R. and Sullivan, E. (1997): Changes in plasma electrolyte concentrations of strenuously exercising thoroughbred horses untreated and treated with furosemide. Proc. Am. Assoc. Equine Practitioners, 43: 273-275.

Gruber, W. (1978): Clin. Chem., 24: 77.

Hakkinen, K. And Pakarinen, A. (1993): Acute hormonal response to two different fatiguing heavy-resistance protocols in male athletes. J. Appl. Physiol., 74 (2): 882-87.

Hamada, M.M.Z. and Radwan, R.M. (1995): Some hormonal and metabolic responses to moderate and heavy exercise loads in women. Mansoura Medical J 25 (1,2): 133-142.

Hamada, M.Z. and El-Badry, A.A. (2002): Applied hematological, metabolic and some hormonal changes in racing camels (camelus dromedarius). Egypt. J. Basic and Appl. Physiol., 1 (2): 341-351.

Henry, R.F.; Cannon, D.; and Winkelman, J. (1974): Editors (Clinical Chemistry Principals & Lechnics), 2nd ed., Harper, & Roe, Hagers Town, M.D.

International Committee for Standardization in Hematology (1967): Brit. J. Haemat., 13: 71-73.

Kirkwood, B.R. (1989): Essentials of medical statistics. Blackwell Scientific Publication. 2nd ed. P. 151.

Knight, P. K.; Cluer, D.; Evan, D. L.; Rose, R. J. and Saltin, B. (1992): Metabolic responses to maximal exercise in the racing camel. Proc. 1st int. Camel Conf. Dubai: 327-329.

Knight, P.K.; Cluer, D.; Manefield, G.W.a ndGorde, A.K. (1994a): Haematology in the racing camel at rest: seasonsl and training variations. Acta Physiol. Scand. Sup., 617: 19-23.

Knight, P.K.; Rose, R.J.; Evans. B.L.; Cluer, D.; Henckel, P. and Saltin, B. 1994b): Metabolic responses to maximal intensity exercise in the racing camel. Acta Physiol. Scand. Supp., 617: 61-71.

McCutcheon, L. J.; Geor, R. J.; Hare, M. j.; Kingston, J. K. and Staempfli, H. R. (1995): Sweat composition: comparison of collection methods and effects of exercise intensity. J. Equine Vet., 18: 279-284.

Medbo, J.I. and Burgers, S. (1990): Effect of training on the anaerobic capacity. Med. Sci. Sports Exer., 22: 501-507.

Miller, S.E. and Seward, J.M. (1971): Textbook of Clinical Pathology. 8th ed., the Williams and Wilkings and Wilking Cmompany Boltimore.

Mohamed, H. A. and Hussein, A. N. (1999): Studies on normal hematological and serum biochemical values of the Hijin racing camels. Vet. Res. Commun., 23 (4): 241-248.

Neville, J.F. and Gelder, R.I. (1971): Enzymatic determination of lactic acid in plasma. Am J. Clin. Path., 55: 152-154.

Pisano, J.J. (1962): Determination of 3-methoxy-4-hydroxymandelic acid in urine. Clin Chem Acta, 7: 285-91.

Pritchard, J.; Despres, J.P.; Gagnon, J.; et al. (1999): Plasma adrenal, gonadal, and conjugated steroids following long-term exercise-induced negative energy balance in identical twins. Metab., 48 (9): 1120-1127.

Reitman, S. and Frankel, S. (1957): Colorimetric determination of GOT and GPT activity. Am. J. Clin. Path., 28: 56-59.

Rose, R.J.; Cluer, D.; Saltin, B. (1994): Some comparative aspects on the camel as a racing animal. Acta Physiol. Scand. Supp. 617: 49-60.

Saltin, B.; Bangsbo, B.; Graham, T.; and Johansen, L. (1992): Metabolism and performance in exhaustive intense exercise. In: Muscle fatigue mechanisms in exer-

cise and training. Marconnet, P., eds, Med. Sport Sci., Basel Karger, 43: 87-114.

Saltin, B.; Rose, R.J. and Henckel, P. (1994): Skeletal muscle morphology and metabolic potential. Act. Physiol. Scand. Suppl., 617: 24-32.

Sarwar, A. and Majeed, M.A. (1997): Interrelationships between 30 parameters of blood in normal one-humped camel in summer. J Camel Pract. & Res.; 4: 35-39.

Schlaghecke, R; Kamely, E; Sonlen, R and Ridderskamp, P (1992): The effect of long-term glucocorticoids on pituitary-adrenal responses to exogenous corticotropin-releasing hormone. J. N. Engl Med., 326: 226-30.

SjoGaard, G. (1990): Exercise induced muscle faligue: the significance of potassium. Acta physiol. Scand., 140 (supl. 593): 1-63.

Snow, D. H.; Billah, A. and Ridha, A. (1988a): Effects of maximal exercise on the blood composition of the racing camel. Vet. Rec., 123: 311-312.

Snow, D.H. and Harris, R.C. (1986): Circualtion, Respiration and metabolism Ed. R. Gilles, Berlin, Springer,Verlag. P. 227.

Snow, D.H.; Harris, R.C.; Stuttard E. (1988b): Changes in haematology and plasma biochemistry during maximal exercise in grey hounds. Vet. Recod.; 123: 487-489.

Stewart, P.M. (1983): Modern quantitative acid-base chemistry. Can J Physiol and Pharm 61: 1441-1461.

Taylor, L.E.; Ferrante, P.L.; Kronfel, D.S. and Meacham, T.N. (1995): Acid-base variables during incremental exercise in sprint-trained horses fed a high fat diet. J Anim Sci, 73: 2009-2018.

Tejero, E.; Estepa, J. C.; Lopez, I.; Bas, S.; Mayer-Voler, R. and Rodriguez, M. (2000): Quantitative analysis of acid-base balance in show jumpers before and after exercise. Res. Vet. Sci., 68: 103-108.

Trinder P. (1969): Determination of glucose in blood using glucose oxidase with an alternative oxygen acceptor. Ann. Clin. Biochem., 6: 24-26.

Varley, H.; Gowenlock, A. and Bell, M. (1980): Colorimetric quantitative determination of plasma lactate dehydrogenase. Pract. Clin. Biochem., 5th ed., 1: 1306-10.

Werney, U. and Kaaden, O. R. (1995) Infectious diseases of Camelids. Blackwell Wissenschafts-Verlag, Berlin.

West, J.B. (1990): Respiratory physiology-the essentials. Baltimore, Williams and Wilkins, pp. 167-168.

Wintrobe, M.M. (1967): In Clinical Haematology. 6th ed. Lea and Febier, Philadelphia, 427-415.