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PHYSICAL AND PHYSIOLOGICAL RESPONSE OF CAMELS TO EXERCISE

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SUMMARY

Eight healthy 5-10 years aged female one humped camels (Camelus dromedarius) were used to run at mid-day either for one hour or for two hours during summer (August) and during winter (January). Respiration rate (RR), rectal temperature (RT), skin temperature (ST) and coat temperature (CT) were recorded just per-exercise, just after exercise and after one, two and three hours of rest. Blood samples were collected at the same schedule for the determination of gtucose, urea and total protein concentrations and alkaline phosphatase and aspartate and alanine aminotransferases enzymes activities. In addition, hemoglobin concentration, packed cells votume and red blood cells, white blood cells and leukocytes differential counts were also evatuated.

Exercised camels revealed slight elevations in RT, ST and CT as compared to that in RR. This may reflect that camels tended to maintain their body temperature under muscular activity stress relatively close to that at rest by activation of evaporative cooling mechanisms through respiratory tract and skin. The onset of exercise is followed by rapid glycogenolysis in the liver cells that causes some cellular impairment as indicated by prolonged elevation in glucose and enzymes activities following exercise and through rest hours. Exercised camels revealed prolonged elevations in blood urea and total protein concentration. Splenic contraction followed the onset of exercise as indicated by marked elevations in RBCs, hemoglobin concentration and packed cells volume. Leukocytosis, neutrophilia, eosinophilia and monocytosis occurred following the onset of exercise. In general, racing at mid-day during summer may affect the camels greater than during winter.

INTRODUCTION

Nearly 80% of the world dromedary population are raised in the hot zones of northern Africa (FAO, 1979) of which about 232 thousands are raised in Egypt (Central Agency for Public Mobilization and Staistics, June 1994). A good fraction of that population (12683) is domesticated at the northwestern coastal area of Egypt (Ministry of Agriculture and Land Reclaimation, 1993). The long dry season in such area is characterized by scarcity of drinking water and food resources as well as harsh climatic conditions. Thus, nomadics and their camels usually used to travel for long distances searching for natural vegetation and water. In addition, camels may also be used as back animals to carry loads for long distances under such adverse desert conditions. On the other hand, it is well known that many Arabian countries and recently Egypt use camels as racing animals.

The experiment was designed to throw some ligh on camel's response to hard work under moderat and adverse climatic conditions.

MATERIALS AND METHODS

Eight healthy female camels aged 5-10 years old were used to run at a relatively constant rate, in a circulating path, inside a bounded yard of about 450 m^2 area. The exercise was carried out at mid-day either for one hour or for two hours in mid-winter (January) and in mid-summer (August). Ambient temperature prevailed during racing periods in winter and summer was 17.3±0.2 and 42.3±1.4°C, respectively. Relative humidity varied from 63.8±0.3 % in January to 29.5±2.8% in August.

Respiration rate (RR) (counts / minute), rectal temperature (RT) (°C), skin temperature (ST) (°C) and coat temperature (CT) (°C) were recorded just pre-exercise, just after each racing period and after 1,2 and 3 hour-rest. Jugular blood samples were also collected at the same schedule.

Anticoagulated whole blood samples, using EDTA (ethylene diamine tetra acetic acid), were used for the erythrocytes (RBCs) (10^6 / cmm) and leukocytes (10^3 / cmm) counts by using a hemocytometer (Kolmer et al., 1951). These samples were also used for the preparation of blood smears stained with Leishman's stain for the differential white blood cells counts (10^3 / cmm) (band neutrophils, BN; segmented neutrophils, SN; eosinophils, EOS; lymphocytes, LYM and monocytes, MON). Heparinized whole blood samples were used for the determination of hemoglobin (HB) concentration (Crosby et al., 1954) and blood glucose (Glu) (Nelson, 1944 and Somogyi, 1945). Plasma separated from the heparinized blood samples was used for the determination of urea (Patton and Crouch, 1977), alkaline phosphatase (ALP) (Belfield and Goldberg 1971), total protein (TPR) (Weichselbaum, 1946) and aspartate aminotransferase (AST) and alanine aminotransferase (ALT) (Reitman and Frankel, 1957).

Analysis of variance and Duncan's muliple range test between means of the percentage of all parameters, relative to their pre-exercise values, were carried out by using the statgraph program (version 5). The averaged pre-exercise values of all measured parameters of the camels are illustrated in table (1).

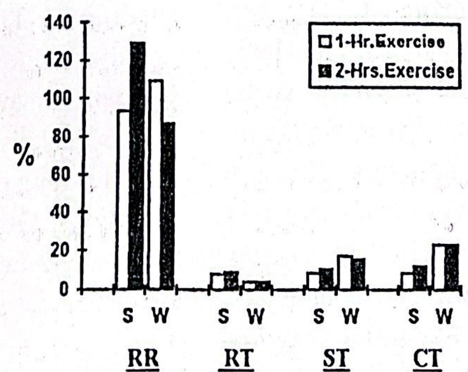

Fig.(1)- Percentage change from pre-exercise values of respiration rate (RR), rectal temperature (RT), skin temperature (ST) and coat temperature (CT) of raced camels during summer (S) and winter (W).

RESULTS AND DISCUSSION

1- Thermoregulatory Response:

Figure (1) revealed that RR, RT, ST and CT were markedly elevated from their pre-exercise values after racing of camels either for one hour or for two hours during summer and winter. Although RT was elevated by about 8% and 9% of its pre-exercise value after 1-hr. and 2-hr.racing during summer, respectively, it was increased only by about 4% following both racing periods during winter. These elevations in RT were steadily recovered to the normal values within the three hours of rest (Table 2-A). The highly significant seasonal variation ($P<0.01$) in RT either after 1-hr. or 2-hr. exercise (Table 2-B) may reflect the combined effect of climatic and metabolic heat load on exerised camels during summer. The slight increase in RT of camels after high intensity exercise may reflect that raced camels tended to maintain their body temperature within a few degrees of that at rest by activation of some thermoregulatory mechanisms. The results revealed also an elevation in ST and CT of raced camels of about 8-9% and 10-12% from their pre-exercise values after 1-hr. and 2-hr. exercise during summer, respectively. Higher elevations of about 16% and 23% of normal values of ST and CT, respectivley, were recorded after each racing period during winter. It can be noticed from table (2-A) that recovery of ST and CT to normal values, during both seasons, was rapid (within the 2nd hour of rest) after 1-hr. extercise but it needed more than three hours of rest after 2-hr. exercise. The slight increase in ST and CT of raced camels during summer may reffect the evaporative cooling through skin as a means of heat dissipation. In this respect, El-Zeiny (1986) found that, inspite of the fact that the camel possesses fairly-active sweating devices, yet this species does not exploit these thermoregulatory device's capabilities under resting conditions by producing a plug of high-viscosity and polysaccharide-rich sweat instead of the usual watery sweat which is only produced under considerable motor activities as in running or walking loaded for long periods of time. The significant seasonal differences in ST

Table (1)- Mean pre-exercise values (±S.E.) of all measured parameters of the camels during summer and winter.

	SUMMER		WINTER	
	1-hr. Exercise	2-hr. Exercise	1-hr. Exercise	2-hr. Exercise
Respiration rate (counts/minute)	16.6 ± 1.0	16.8 ± 1.6	19.5 ± 0.9	18.0 ± 1.9
Rectal temperature (°C)	37.0 ± 0.1	37.0 ± 0.1	37.3 ± 0.1	37.2 ± 0.2
Skin temperature (°C)	31.4 ± 0.7	30.3 ± 0.4	35.3 ± 0.2	33.9 ± 0.4
Coat surface temperature (°C)	29.8 ± 0.9	28.9 ± 0.3	35.3 ± 0.2	33.5 ± 0.4
Glucose (gm./100ml)	81.4 ± 12.1	72.8 ± 11.8	86.5 ± 3.6	97.5 ± 3.7
Urea (µmole/l)	5.1 ± 0.2	5.9 ± 0.2	5.5 ± 0.2	5.7 ± 0.1
Alkaline phosphatase (iu/l)	17.2 ± 1.4	15.4 ± 0.8	32.1 ± 3.4	31.3 ± 2.2
Total protein (gm/100ml)	7.4 ± 0.1	5.1 ± 0.2	7.2 ± 0.1	6.9 ± 0.2
Aspartate aminotransferase (iu/l)	32.4 ± 2.1	31.4 ± 1.9	28.9 ± 2.6	31.3 ± 2.6
Analine aminotransferase (iu/l)	8.1 ± 0.4	9.0 ± 0.6	9.6 ± 0.4	10.4 ± 0.3
Haemoglobin (mg/l)	186.5 ± 13.7	174.0 ± 6.0	124.6 ± 6.1	117.9 ± 6.5
Packed cells volume	32.8 ± 2.2	34.0 ± 2.5	27.0 ± 1.2	28.6 ± 1.4
Red blood cells (x 10^6)	5.7 ± 0.5	6.3 ± 0.5	6.0 ± 0.6	6.2 ± 0.6
White blood cells (x 10^3)	17.1 ± 1.8	15.8 ± 1.2	17.4 ± 0.8	12.5 ± 1.6
Band neutrophils (x 10^3)	0.43 ± 0.05	0.43 ± 0.06	0.61 ± 0.05	0.35 ± 0.07
Segmented neutrophils (x 10^3)	6.54 ± 0.70	6.16 ± 0.50	6.76 ± 0.30	4.74 ± 0.60
Basophils (x 10^3)	0.13 ± 0.05	0.10 ± 0.03	0.09 ± 0.04	0.08 ± 0.03
Eosinophils (x 10^3)	1.26 ± 0.20	1.09 ± 0.10	1.18 ± 0.08	0.81 ± 0.11
Lymphocytes (x 10^3)	6.96 ± 0.80	6.81 ± 0.60	7.55 ± 0.30	5.29 ± 0.67
Monocytes (x 10^3)	1.68 ± 0.20	1.28 ± 0.10	1.20 ± 0.08	1.04 ± 0.13

(P<0.05) and CT (P<0.01) (Table 2-B) either after 1 - hr. or 2-hr. exercise of camels with their higher elevations during winter than summer may be due to the seasonal variation in camel's coat length and nature where it gets long (~ 8-cm.) and dense during winter and short (~3cm.) and sparse during summer (El-Hassanein, 1989).

Although camels are well known as non-panting animals, the results revealed high elevations in RR of raced camels either after 1-hr. or 2-hr. exercise during summer (93% and 129% above their pre-exercise values, respectively) and during winter (109% and 87%). Folding of RR by up to 2.3 times its normal value after 2-hr. racing during summer may reflect that, in adition to get enough amount of oxygen for metabolic activities and to get rid of metabolic by-products, the raced camels activated their respiratory tract evaporative cooling mechanisms as a means of heat dissipation in addition to the cutaneous thermoregulation. It can be noticed from table (2-A) that the increased RR of raced camels steadily recovered to their pre-exercise values within the three hours of rest after each racing period during both seasons.

II-Biochemical Response:

Exercised camels showed a marked elevation in the blood glucose concentration (Fig.2). It is curious that Glu elevation after 1-hr. exercise during summer reached about 61% of its pre-exercise value and this elevation tended to increase up to 124% after 3-hr. of rest (Table 2-A). On the contrary, 2-hr. exercised camels showed a relatively lower elevation of about 30% which tended to decline during the rest hours. The same trend of Glu elevation after the two racing periods during winter was also found, but to a slight extent. These findings may reflect that the onset of exercise rapidly enhanced the glycogenolysis process in the liver which resulted in high elevations in the glucose concentration that was much more than that needed for one hour muscular activity. However, 2-hr. exercise relatively consumed the circulating glucose as energy. Similar observations of increased glucose concentration in raced camels were recorded by Snow et al., (1988) and Evans et al. (1992). It is well known that the maintenance of exercise requires production of sufficient energy to meet the demands necessary for the activity performance. Metabolic demand is met by the conversion of chemical fuel substrates, normaly carbohydrates and fats, into adenosine triphosphate which is the energy currency of the muscular contractile process (Hodgson et al., (1994).

The blood urea concentration was markedly elevated after racing of camels either for 1-hr. or 2-hr. during summer (34% and 31% above normal values, respectively) and during winter (29% and 20%) (Fig. 2). In addition, table (2-A) reflects that urea concentration remained higher than its pre-exercise value within the rest periods after each racing during both seasons. Similar increase in blood urea of raced camels was also found by Evans et al., (1992) and El-Anwar et al., (1993). The elevation in blood urea of exercised camels may be probably due to the combined prerenal effects of reduced infusion with lower glomerular filtration and greatest load from increased metabolic activity (Snow et al., 1988).

The results revelaed an elevation in plasma TPR concentration of raced camels either after 1-hr. or 2-hr. exercise during summer (24% and 33% above normal values, respectively) or during winter (18% and 38%) (Fig. 2). Although TPR concentration after 1-hr. exercise during both seasons relatively recovered to normal values after 3 hour-rest (Table 2-A), it remained higher than its pre-exercise values after the same period of rest following 2-hr. exercise during summer (14%) and winter (24%).

Table (2) - Average Percentage (relative to pre-exercise values) Of The Physical And Biochemical Parameters Of Camels Exposed To Different Regimes Of Exercise In Different Seasons .

(2-A)- Exercise And Rest Periods Within Each Season :

SEASON	EXERCISE & REST PERIODS (hr.)	RR	RT	ST	CT	Glu	Urea	ALP	TPR	AST	ALT
SUMMER	1-hr.Exercise	193.3 a	107.6 a	108.5 a	108.1 a	161.4 a	133.5 a	170.6 a	123.5 a	211.5 a	258.5 a
	1-hr.Rest	130.4 b	104.2 b	100.2 b	101.1 b	179.4ab	129.3 a	144.5 a	112.1 b	174.6 a	217.2 b
	2-hr.Rest	104.4 c	102.4bc	96.4 b	96.4 b	196.6ab	126.2 a	127.0 a	110.1 b	165.9 a	176.2 c
	3-hr.Rest	92.5cd	100.9 c	97.1 b	97.1 b	223.9 b	125.3 a	135.7 a	107.1 b	143.4 a	130.2 d
	SED (±)	11.7	0.7	1.4	1.7	15.8	4.0	16.6	3.4	19.2	12.5
	Exercise vs. Rest	**	**	**	**	NS	NS	NS	*	NS	**
	2-hr.Exercise	229.2 a	108.6 a	110.2 a	111.8 a	130.0 a	130.5 a	187.0 a	132.8 a	204.0 a	238.8 a
	1-hr.Rest	135.3 b	106.2ac	106.3 b	108.4 b	106.6 b	145.8 b	138.6 b	113.3 b	182.7 a	206.7 b
	2-hr.Rest	121.9 b	104.3bc	105.0 b	106.5 b	119.9ab	132.8 a	146.4 b	110.4 b	162.1 a	171.3 c
	3-hr.Rest	100.2 b	102.0 b	105.1 b	106.1 b	120.4ab	127.2 a	139.1 b	114.0 b	147.0 a	128.9 d
	SED (±)	17.8	1.0	1.0	0.9	5.1	4.1	12.4	4.2	19.2	10.2
	Exercise vs. Rest	**	**	**	**	*	*	*	**	NS	**
WINTER	1-hr.Exercise	209.3 a	104.1 a	116.8 a	123.0 a	124.0 a	129.1 a	152.8 a	117.7 a	175.1 a	264.5 a
	1-hr.Rest	130.0 b	101.5 b	107.6 b	113.6 a	127.1 a	133.9 a	117.4 a	116.4 a	132.2 b	256.4 a
	2-hr.Rest	127.6 b	102.0 b	94.0 c	96.0 b	114.3 a	128.4 a	136.2 a	121.3 a	123.2 b	230.3 a
	3-hr.Rest	110.6 b	100.6 b	88.3 c	93.7 b	144.6 a	130.3 a	118.8 a	106.2 a	132.7 b	132.5 b
	SED (±)	14.1	0.6	3.1	4.1	18.1	8.1	20.1	5.1	8.8	13.7
	Exercise vs. Rest	**	**	**	**	NS	NS	NS	NS	**	**
	2-hr.Exercise	186.6 a	104.4 a	115.6 a	123.1 a	125.6 a	119.6 a	169.3 a	138.0 a	179.5 a	321.4 a
	1-hr.Rest	133.0 b	101.8 b	104.2bc	107.4bc	136.1 a	106.7 a	135.6ab	130.9 a	131.4 b	246.2 b
	2-hr.Rest	122.9 b	101.5 b	108.3 b	111.1 b	110.5 a	114.4 a	122.5 b	122.1 a	120.3 b	215.7 b
	3-hr.Rest	102.2 b	100.9 b	101.0 c	102.3 c	129.8 a	114.0 a	138.7ab	123.6 a	126.0 b	117.8 c
	SED (±)	12.0	0.4	2.0	2.3	12.3	4.5	12.3	6.6	10.4	15.9
	Exercise vs. Rest	**	**	**	**	NS	NS	NS	NS	**	**

(2-B)- Exercise Periods Within Each Season :

EXERCISE PERIOD(hr.)	SEASON	RR	RT	ST	CT	Glu	Urea	ALP	TPR	AST	ALT
1-hr. EXERCISE	Summer	193.3 a	107.6 a	108.5 a	108.1 a	161.4 a	133.5 a	170.6 a	123.5 a	211.5 a	258.5 a
	winter	209.3 a	104.1 b	116.8 b	123.0 b	124.0 a	129.1 a	152.8 a	117.7 a	175.1 a	264.5 a
	SED (±)	19.3	0.7	2.3	3.4	15.1	3.2	20.4	3.2	14.2	19.7
	Between Seasons	NS	**	*	**	NS	NS	NS	NS	NS	NS
2-hr. EXERCISE	Summer	229.2 a	108.6 a	110.2 a	111.8 a	130.0 a	130.5 a	187.0 a	132.8 a	204.0 a	238.8 a
	Winter	186.6 a	104.4 b	115.6 b	123.0 b	125.6 a	119.6 a	169.3 a	138.0 a	179.5 a	321.4 b
	SED (±)	20.6	0.8	1.5	1.3	5.0	4.2	12.9	6.0	15.1	21.3
	Between Seasons	NS	**	*	**	NS	NS	NS	NS	NS	*

N.B. : Means in the same column in each block and followed by the same letter are not significantly different from each other . RR=Respiration rate; RT=Rectal temperature; ST= Skin temperature; CT= Coat mperature; Glu= Glucose; ALP= Alkaline phosphatase; AST= Aspartate aminotransferase; ALT= Alanine aminotransferase ; SED= Standered error of difference of means; NS= None significant; *= p< 0.05; **= p< 0.01.

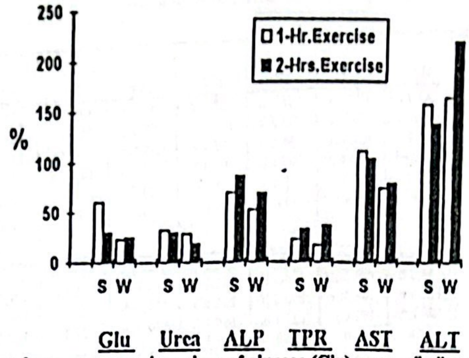

Fig.(2)- Percentage change from pre-exercise values of glucose (Glu), urea, alkaline phosphatase (ALP), total protein (TPR), aspartate aminotransferase (AST) and alanine aminotransferase (ALT) of raced camels during summer (S) and winter (W).

Similar observations of increased plasma TPR concentration in raced camels were also found by Evans et al. (1992) and El-Anwar et al. (1993). The increased plasma TPR concentration in raced camels may be an indication of the incidence of haemoconcentration (Harris and Snow, 1988) which may be due to the loss of considerable amount of body water of camels through sweating (Yagil, 1985).

The activity of plasma ALP and ALT enzymes was elevated after racing of camels either for one hour or two hours during both seasons. Elevations in ALP and AST activities due to racing reached their maximal values (87% and 104% above their normal values, respectively) after 2-hr. exercise during summer, however, ALT activity was maximal (321%) after 2-hr. exercise during winter. In general, the activity of the three enzymes showed prolonged elevations above their normal values up to the three hours of rest (Table 2-A). Similar observations of increased ALP and AST activities were also found in raced camels by El-Anwar et al. (1993). On the other hand, Sommer (1983) found that racehorses with impaired metabolism had increased activities of creatine kinase, AST, lactate dehydrogenase and gamma-glutamyl transferase, while those with impaired liver metabolism were indicated by raised gamma-glutamyl transferase and bilirubin values. It is a fact that ALP and AST enzymes are intracellularly bounded and that the increase in their circulating levles in plasma may be indicative to cellular destructions (Varly et al., (1980). In the present study, the increased plasma enzymatic activity in the raced camels may be indicative of some liver cellular impairment due to rapid glycogenolysis as a response to intense exercise.

III- Hematological Response:

RBCs, HB and PCV were markedly elevated after racing for one hour (56%, 33% and 14% above their normal values, respectively) and for two hours (70% 37% and 8%) during summer (Fig. 3). The same trend of elevation in RBCs, HB and PCV was also found during winter but to a slight extent. The results in table (3-A) revealed that while elevations in RBCs remained higher than their normal values within the rest hours after 1-hr. exercise during both seasons, they recovered rapidly to their pre-exercise values within the second hour of rest after 2-hr. exercise.

Recovery of HB and PCV to their normal values was relatively slower during summer than during winter after both racing periods. Similar observations of increased HB concentration and/or P'CV value after racing were also found in camels (Snow et al., 1988) and in horses (Martinez et al., 1988 and McKeever et al., 1993). It is well known that the spleen is an important

also to releasing of catecholamines. Under such conditions there will be an increase of erythrocytes count, PCV value and HB concentration (Melvin, 1977). In adition, Martinez et al., (1988) found that the increases in PCV of racehorses were correlated to increases in catecholamines which were increased by 6-7 fold. On the other hand, McKeever et al. (1993) found that racehorses showed a marked decrease in plasma volume which may be due to shifting of fluid from the vascular compartment into the interstitial space as a result of exercise-induced increases in hydrostatic pressure. The increased RBCs, HB and PCV of raced camels may be propably due to splenic contraction and / or haemoconcentration. Figure (3) revealed also that WBCs were elevated by about 33-34% of their normal values after 1-hr. exercise of camels during both seasons. However, a significant seasonal variation ($P<0.05$) was found after 2-hr.

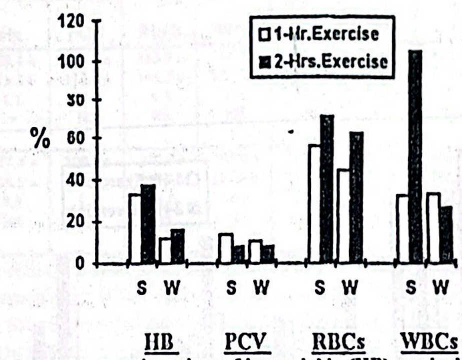

Fig.(3)- Percentage change from pre-exercise values of hemoglobin (HB), packed cells volume (PCV), red blood cells (RBCs) and white blood cells (WBCs) of raced camels during summer (S) and winter (W).

reservoir of blood to be called upon when the body has a greater need for oxygen in the tissues. Thus, the onset of exercise leads primarly to splenic contraction and exciting the animal leads

exercise between summer (204% of their normal value) and winter (127%) WBCs. counts of raced camels (Table 3-B). Although WBCs remained higher than their normal values within the rest hours after summer racing (Table 3-A), it tended to recover rapidly after racing in winter. Similarly, Lassen et al., (1986) found a significant increase in WBCs of raced dogs. It has been suggested that the delayed leukocytosis (up to 235 percent increase at 5 hours post exercise) may be related to marrow release of leukocytes (McCarthy et al., 1987). On the other hand, fig. (4) showed a marked neutrophilia following racing of camels either for one hour or for two hours during both seasons. It is noticeable that elevations in BN were almost higher than those in SN. Maximal elevations in BN and SN (28% and 120% above their normal values, respectively) were observed after 2-hr. exercise during summer. It has been reported that following exercise neutrophilia occurs (Melvin, 1977 and Christensen and Hill, 1987), and neutrophilia is directly related to the work load and cardiac output (Thormas and Robert, 1991). Table (3-A) revealed that elevations in neutrophils extended through the rest hours, specially that in BN. Prolonged elevations in BN and SN may reflect the marrow release of leukocytes under exercise stress (Mc Carthy et al, 1987).

In addition, BAS and EOS revealed an elevation after 1-hr. exercise (18% and 94% above their normal values, respectively) and after 2-hr. exercise (85% and 196%) during summer (Fig. 4). The same trend was also observed during winter but to a slight extent. Elevations in BAS and EOS tended to decline within the rest hours after summer and winter racing (Table 3-A) but remained higher than their normal values after the three hours fo rest. In respect of the agranulocytes, LYM revealed a marked elevation only after 2-hr. exercise during summer (46% above its normal value), however, MON increased markedly after each racing period during both seasons. Maximal elevations in MON were almost recorded after 2-hr. racing either during summer (175% above its baseline value) or during winter (85%). Table (3-B) reveals a significant seasonal difference (P<0.05) either after 1-hr. or 2-hr. exercise in MON counts with higher elevations recorded during summer.

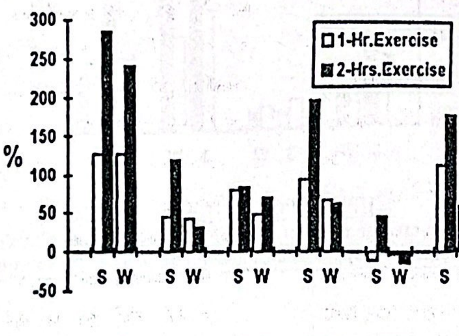

Fig.(4)- Percentage change from pre-exercise values of band neutrophils (BN), segmented neutrophils (SN), basophils (BAS), eosinophils (EOS), lymphocytes (LYM) and monocytes (MON) of raced camels during summer (S) and winter (W).

Table (3) - Averaged Percentage (relative to pre-exercise values) Of Hematological Parameters Of Camels Exposed To Different Regimes Of Exercise In Different Seasons .

(3-A) - Exercise And Rest Periods Within Each Season :

SEASON	EXERCISE & REST PERIODS (hr.)	HB	PCV	RBCs	WBCs	BN	SN	BAS	EOS	LYM	MON
SUMMER	1-hr.Exercise	133.2 a	113.6 a	155.9 a	132.7 a	227.4 a	145.5 a	180.8 a	194.8 a	89.7ab	211.9 a
	1-hr.Rest	110.1 b	106.0 a	105.5 b	113.4 b	151.7 b	120.4 b	171.2ac	147.9 b	86.7a	166.9 b
	2-hr.Rest	114.7 b	106.3 a	124.6ab	111.7 b	133.9 b	111.6 b	144.3bc	149.8 b	93.2ab	128.3 b
	3-hr.Rest	108.9 b	108.8 a	110.3 b	110.1 b	115.3 b	110.5 b	115.8 b	130.7 b	99.5 b	133.3 b
	SED (±)	3.8	2.7	14.7	4.2	18.4	4.1	10.5	11.1	3.9	9.8
	Exercise vs. Rest	*	NS	NS	**	**	**	**	**	NS	**
	2-hr.Exercise	137.4 a	108.2 a	170.3 a	204.0 a	385.3 a	219.5 a	184.5 a	295.6 a	146.3 a	275.3 a
	1-hr.Rest	133.5 a	105.2 a	96.3 b	173.8ab	256.2ab	182.5ab	170.6 a	242.2ac	142.5 a	209.8 b
	2-hr.Rest	137.6 a	103.0 a	98.0 b	156.2 b	214.7 b	166.4 b	128.9 b	184.4bc	137.8 a	179.3bc
	3-hr.Rest	127.9 a	100.3 a	106.6 b	131.0 b	164.9 b	143.1 b	114.6 b	141.1 b	122.0 a	129.9 c
	SED (±)	8.3	3.7	11.4	14.9	52.6	15.2	7.6	24.2	11.0	20.0
	Exercise vs. Rest	NS	NS	**	*	*	*	**	**	NS	**
WINTER	1-hr.Exercise	112.1 a	110.8 a	144.3 a	133.6 a	226.9 a	143.6 a	149.6 a	166.9 a	96.5 a	159.0 a
	1-hr.Rest	93.9 ab	101.6 b	126.5ab	113.2ab	165.1 b	116.9ab	112.3 b	147.9ab	101.9 a	124.9ab
	2-hr.Rest	100.1ab	96.3 b	109.9 b	107.1 b	145.6 b	110.6 b	127.9ab	139.7ab	96.1 a	116.0ab
	3-hr.Rest	91.0 b	97.6 b	135.7ab	97.1 b	135.9 b	98.2 b	103.7 b	122.1 b	91.9 a	102.1 b
	SED (±)	6.1	2.8	10.1	7.8	21.2	10.0	9.7	13.7	10.2	15.5
	Exercise vs. Rest	NS	**	NS	*	*	*	*	NS	NS	NS
	2-hr.Exercise	116.0 a	108.0 a	162.2 a	126.9 a	341.3 a	131.7 a	171.5 a	163.1 a	85.1 a	185.4 a
	1-hr.Rest	101.5 a	101.0 b	132.1 a	106.0 b	334.9 a	103.6 b	136.8 b	117.9 b	84.2 a	157.2ab
	2-hr.Rest	103.8 a	94.7 b	94.4 b	111.9 b	177.2 b	115.1 b	124.1bc	127.0 b	97.5bc	129.8 b
	3-hr.Rest	98.4 a	95.3 b	87.0 b	105.4 b	160.0 b	107.0 b	106.5 c	107.5 b	98.3 c	111.7 b
	SED (±)	6.5	3.0	11.5	4.2	30.7	4.1	7.1	8.2	3.9	16.1
	Exercise vs. Rest	NS	*	**	**	**	**	**	**	*	**

(3-B) - Seasons Within Each Exercise Period :

EXERCISE PERIOD(Hr.)	SEASON	Hg	PCV	RBCs	WBCs	BN	SN	BAS	EOS	LYM	MON
1-hr. EXERCISE	Summer	133.2 a	113.6 a	155.9 a	132.7 a	227.4 a	145.5 a	180.8 a	194.8 a	89.7 a	211.9 a
	Winter	112.1 b	110.8 a	144.3 a	133.6 a	226.9 a	143.6 a	149.6 a	166.9 a	96.5 a	159.0 b
	SED(±)	6.1	3.6	9.5	6.5	28.9	9.3	11.5	12.1	11.4	14.8
	Between Seasons	*	NS	NS	NS	NS	NS	NS	NS	NS	*
2-hr. EXERCISE	Summer	137.4 a	108.2 a	170.3 a	204.0 a	385.3 a	219.5 a	184.5 a	295.6 a	146.3 a	275.3 a
	Winter	116.0 a	108.0 a	162.2 a	126.9 b	341.3 a	131.7 b	171.5 a	163.1 b	85.1 b	185.4 b
	SED(±)	8.9	1.5	16.0	16.5	65.3	16.1	10.2	29.7	10.9	24.9
	Between Seasons	NS	NS	NS	*	NS	**	NS	**	**	*

N.B. : Means in the same column in each block and followed by the same letter are not significantly different from each other. HB= Hemoglobin; PCV= Packed cell volume; RBCs= Red blood cells; WBCs= White blood cells; BN= Band neutrophils ; SN= Segmented neutrophils; BAS= Basophils; EOS= Eosinophils; LYM= Lymphocytes; MON= Monocytes . SED= Standered error of difference of means; NS= None significant; *= p< 0.05; **= p< 0.01 .

In conclusion, the experiment reflects that the exercised camels tended to maintain their body temperature within few degrees above that at rest by activation of cutaneous and respiratory tract evaporative cooling mechanisms. The onset of exercise is followed by rapid glycogenolysis in the liver cells that causes some cellular impairment as indicated by prolonged elevations in enzymes activity. In addition, splenic contraction following exercise stress resutls in high elevations in RBCs and HB concentration to meet the demand of oxygen for muscular activities.

On the other hand, leukocytosis, neutrophilia, eosinophilia and monocytosis occur following high intensity exercise of camels as a result of stress stimulation on bone marrow. In general, the recovery of camels to their normal state following summer racing was markedly slower than that following winter racing.

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