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The Influences of Thermal Stress on Serum Biochemical Parameters of Dromedary Camels and Their Correlation with Thyroid Activity

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Abstract. In order to study the influences of thermal stress on serum biochemical parameters of dromedary camels and their correlation with thyroid activity, blood samples were taken from the jugular vein of 40 clinically healthy Iranian dromedary camels from December to February (3 times: mean temperature 11 °C) and from June to August (3 times: mean temperature 41 °C). There were significant differences in the concentrations of serum total protein, glucose, blood urea nitrogen (BUN), sodium, potassium, calcium, inorganic phosphorus, triiodothyronine (T3) and thyroxine (T4) and the activities of aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP), creatine kinase (CK) and lactate dehydrogenase (LD) in heat stress and cold stress conditions ($p < 0.05$).

The concentrations of BUN, sodium, potassium, calcium, inorganic phosphorus and the activities of CK and LD in winter months were higher than summer months, and in contrast, the concentrations of total protein, glucose, T3 and T4 and the activities of AST, ALT and ALP were higher in summer than in winter ($p < 0.05$). Thyroidal hormones (T3 and T4) showed significant correlations with serum total protein, glucose, BUN, AST, ALT, ALP, LD and CK. Our results revealed that very hot and cold conditions had a profound effect on serum biochemical parameters.

Keywords: Biochemical parameters; Dromedary camel; Serum; Thermal stress; Thyroxine (T4); Triiodothyronine (T3)

Introduction

Of all the domesticated animals, the camel occupies a unique place for its tolerance of heat stress and capacity to get along remarkably well for long periods without water. The camel, with its large body mass, heats up slowly when exposed to direct sunlight compared to animals with small bodies. The camel usually sweats only when the atmospheric temperature exceeds 42 °C, and even at this temperature, the secretion is not continuous. Its ability to utilise internal water, especially during the periods of dehydration and to withstand adverse climatic conditions appears to be due to the physiological behaviour of its internal systems (Mehrotra and Gupta 1989). The physiological responses of the animals to environmental stress during the winter and summer, and their energy balance, showed that seasonal heat and cold stress have profound effects on serum biochemical parameters (Barakat and Abdel-Fattah 1971; Rowlands et al. 1979; Eldon et al. 1988; Kataria and Bhatia 1991; Kataria et al. 1991, 1993; Soveri et al. 1992; Bengoumi et al. 1997).

Thyroid hormones are known to be important modulators of developmental processes and general metabolism (Kaneko 1989). Seasonal variations in the concentration of serum thyroxine (T4) and triiodothyronine (T3) of the camel, goat, mare and dog have been reported (Yagil et al. 1978; Prakash and Rathore 1991; Flisinska-Bojanowska et al 1991; Tuckova et al. 1995), but whether there was any correlation between various serum biochemical parameters and thyroid hormones of dromedary camels in heat and cold conditions has not been determined.

The present study provides data about the effects of thermal stress on serum biochemical parameters of

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dromedary camels and their correlation with thyroid activity.

Materials and Methods

Animals

The investigation was carried out on male Iranian camels (*Camelus dromedarius*) which were reared mainly in central Iran (Yazd province). Forty camels, aged between two and three years were screened for this study. All the animals were clinically healthy and free from internal and external parasites. All the camels were treated with febendazole (10 mg/kg) 30 days before the study.

Blood Sampling

The animals were bled six times to study the effect of thermal stress, three times from December to February and three times from June to August. The mean atmospheric temperature during the December–February period was 11 °C, whereas for June–August, it was 41 °C. Blood was collected in the morning, before feeding and watering, from a jugular vein under aseptic conditions directly into test tubes without any anticoagulant. The serum was separated following centrifugation for 15 min at 3000 r.p.m., and any haemolysed samples were discarded. Serum samples were stored at −20 °C until analysed.

Analytical Methods

Serum total protein was performed by the Biuret method, glucose by the *o*-toluidine method, urea nitrogen by the diacetyl monoxime method, uric acid by the phosphotungstic acid (PTA) method, chloride by the colorimetric (mercuric nitrate) method, and inorganic phosphorus by the ammonium molybdate method.

Activities of aspartate aminotransferase (AST) and alanine aminotransferase (ALT) were determined by the colorimetric method of Reitman and Frankel, lactate dehydrogenase (LD) by the Sigma colorimetric (Cabaud Wroblewski) method, creatine kinase (CK) by the Sigma colorimetric (Modified Hughes) method, and alkaline phosphatase (ALP) by the modified method of Bowers and McComb. All the enzyme activities were measured at 37 °C and the results presented in U/l (Burtis and Ashwood 1994).

The concentration of sodium and potassium in the serum was measured by a flame photometric method (Flame photometer, FLM2, Ontario, Canada).

Magnesium and calcium were analysed using an atomic absorption spectrophotometer (Shimadzo AA-670, Kyoto, Japan).

T4 and T3 were measured by using radioimmunoassay kits in Namazi Medical Research Centre, Shiraz, Iran.

Data were analysed by one way ANOVA and regression analysis using SPSS/PC software, and Duncan's multiple range test was used to detect significant differences among means.

Results

The means and standard errors of serum biochemical parameters of Iranian dromedary camels in different months during winter and summer are presented in Tables 1 and 2, respectively. There were no significant differences in any of the serum biochemical parameters during the different months of each season.

The means and standard errors of serum biochemical parameters of Iranian dromedary camels exposed to the thermal extremes of winter and summer are presented in Table 3. There were significant differences in the concentration of serum total protein, glucose, blood urea nitrogen (BUN), sodium, potassium, calcium, inorganic phosphorus, T3 and T4, and in the activities of AST, ALT, ALP, CK and LD in heat stress when compared to cold stress conditions ($p < 0.05$), with the concentration of BUN, sodium, potassium, calcium, inorganic phosphorus and the activities of CK and LD being higher in winter months, and, by contrast, the concentration of total protein, glucose, T3 and T4 and the activities of AST, ALT and ALP being higher in the summer ($p < 0.05$).

Thyroidal hormones (T3 and T4) were significantly correlated with serum total protein ($p <$;0.05; $r = +0.23$), glucose ($p < 0.05$; $r = +0.46$), BUN ($p < 0.05$; $r = -0.27$), AST ($p < 0.05$; $r = +0.30$), ALT ($p < 0.05$; $r = +0.23$) ALP ($p < 0.05$; $r = +0.40$), LD ($p < 0.05$; $r = -0.45$) and CK ($p < 0.05$; $r = -0.30$) of dromedary camels.

Our results therefore revealed that very hot and very cold conditions had a profound effect on serum biochemical parameters.

Discussion

Thermal stress could alter serum biochemical parameters of Iranian dromedary camels. In our study, the concentrations of serum T4 and T3 in summer were higher than winter ($p < 0.05$). This finding was similar to findings of Yagil et al. (1978),who showed that the thyroid was stimulated in summer when water was available, but was inhibited after dehydration. This inhibition assists in the preservation of body water by decreasing pulmonary water loss and reducing basic metabolism. Similarly, Agarwal et al. (1986) reported that there were highly significant differences in serum concentrations of T4 and T3 in the breeding and non-breeding seasons. Khanna et al. (1996) reported that during the summer, T4 levels fell gradually in dehydrated dromedary camels and increased after rehydration, whereas in the winter, T4 levels increased in dehydrated camels. In our study, all dromedary camels were in normal hydration status. By comparison, Prakash

Table 1. Mean serum biochemical values of Iranian dromedary camels during the Winter months

Biochemical parameter	December	January	February
Total protein (g/l)	53.1 (2.2)	50.9 (1.5)	52.9 (2.2)
Glucose (mmol/l)	5.1 (0.3)	5.0 (0.3)	5.2 (0.3)
Uric acid (mmol/l)	0.1 (0.01)	0.1 (0.01)	0.1 (0.01)
Blood urea nitrogen (mmol/l)	11.0 (0.4)	11.2 (0.6)	11.1 (0.5)
Sodium (mmol/l)	143.4 (0.9)	143.1 (1.0)	143.1 (0.9)
Potassium (mmol/l)	5.1 (0.01)	5.2 (0.02)	5.2 (0.01)
Chloride (mmol/l)	102.3 (2.3)	102.3 (0.6)	124.7 (2.5)
Calcium (mmol/l)	2.6 (0.02)	2.6 (0.01)	2.5 (0.02)
Inorganic phosphorus (mmol/l)	1.9 (0.01)	1.9 (0.01)	1.8 (0.02)
Magnesium (mmol/l)	0.9 (0.03)	0.9 (0.03)	0.9 (0.02)
AST (U/l)	15.1 (5.8)	14.3 (5.2)	15.1 (6.1)
ALT (U/l)	19.3 (2.7)	18.4 (2.3)	19.3 (2.8)
ALP (U/l)	23.5 (2.5)	22.6 (2.7)	23.6 (2.9)
CK (U/l)	197.2 (20.9)	199.5 (21.3)	196.9 (19.7)
LD (U/l)	680.4 (12.5)	693.1 (11.6)	677.3 (12.7)
T3 (nmol/l)	1.99 (0.04)	1.91 (0.06)	2.00 (0.05)
T4 (nmol/l)	104.24 (23.16)	96.52 (16.73)	105.53 (7.72)

n = 40; mean atmospheric temperature = 11°C; Figures in brackets = SE. AST, aspartate aminotransferase; ALT, alanine aminotransferase; ALP, alkaline phosphatase; CK, creatine kinase; LD, lactate dehydrogenase; T3, triiodothyronine; T4 thyroxine.

Table 2. Mean serum biochemical values of Iranian dromedary camels during the Summer months

Biochemical parameter	June	July	August
Total protein (g/l)	66.5 (1.4)	67.4 (1.8)	66.3 (1.2)
Glucose (mmol/l)	7.1 (0.2)	7.2 (0.2)	7.1 (0.2)
Uric acid (mmol/l)	0.1 (0.01)	0.1 (0.01)	0.1 (0.01)
Blood urea nitrogen (mmol/l)	5.5 (0.2)	5.4 (0.3)	5.5 (0.3)
Sodium (mmol/l)	139.9 (0.8)	140.0 (0.9)	139.9 (0.7)
Potassium (mmol/l)	5.0 (0.2)	4.9 (0.2)	4.9 (0.2)
Chloride (mmol/l)	107.5 (2.0)	107.6 (2.2)	107.5 (2.1)
Calcium (mmol/l)	2.4 (0.03)	2.4 (0.1)	2.4 (0.1)
Inorganic phosphorus (mmol/l)	1.8 (0.1)	1.8 (0.04)	1.8 (0.1)
Magnesium (mmol/l)	1.0 (0.1)	1.0 (0.1)	1.0 (0.04)
AST (U/l)	29.1 (0.7)	30.1 (0.8)	28.9 (0.7)
ALT (U/l)	31.7 (4.7)	32.6 (2.2)	31.7 (3.9)
ALP (U/l)	108.3 (8.3)	110.3 (7.5)	108.4 (9.5)
CK (U/l)	89.2 (3.2)	88.2 (4.2)	89.5 (3.0)
LD (U/l)	182.9 (6.9)	180.2 (7.4)	183.1 (6.8)
T3 (nmol/l)	2.62 (0.10)	2.65 (0.10)	2.60 (0.10)
T4 (nmol/l)	168.59 (36.03)	177.60 (21.87)	166.02 (28.31)

n = 40; mean atmospheric temperature = 41°C; Figures in brackets = SE. For abbreviations see Table 1.

and Rathore (1991) reported that in the goat, the concentrations of T3 and T4 are higher in winter than in summer. These authors believed that a cold environment may be a stimulus to increase the output of thyrotrophic hormone thereby resulting in a higher concentration of thyroid hormones in serum. Also, Tuckova et al. (1995) reported that in dogs, the lowest values of T3 and T4 were in summer, the highest T3 concentrations were in winter and the highest T4 concentrations in autumn.

The serum total protein and glucose concentrations of Iranian camels decreased during the winter, due partly to protein and energy deficiency in the diet. Our results were similar to the findings of Soveri et al. (1992) in reindeer calves, but opposite to the findings of Mehrotra and Gupta (1989) in the camel, and Eldon et al. (1988) in dairy cows. Thyroid hormones (T3 and T4) had significant correlations with serum total protein and glucose; among the effects of thyroid hormones are the stimulation of protein synthesis and positive nitrogen

Table 3. Mean serum biochemical values of Iranian dromedary camels exposed to thermally stressful temperatures

Biochemical parameter	Heat stress (41°C)		Cold stress (11°C)	
Total protein (g/l)	66.7	(1.4)[a]	52.3	(2.0)[b]
Glucose (mmol/l)	7.1	(0.2)[a]	5.1	(0.3)[b]
Uric acid (mmol/l)	0.1	(0.01)[a]	0.1	(0.01)[a]
Blood urea nitrogen (mmol/l)	5.5	(0.3)[a]	11.1	(0.5)[b]
Sodium (mmol/l)	140.0	(0.8)[a]	143.2	(0.9)[b]
Potassium (mmol/l)	4.9	(0.9)[a]	5.2	(0.01)[b]
Chloride (mmol/l)	107.5	(2.1)[a]	109.8	(2.5)[a]
Calcium (mmol/l)	2.4	(0.04)[a]	2.6	(0.02)[b]
Inorganic phosphorus (mmol/l)	1.8	(0.1)[a]	1.9	(0.01)[b]
Magnesium (mmol/l)	1.0	(0.1)[a]	0.9	(0.03)[a]
AST (U/l)	29.4	(0.7)[a]	14.8	(5.7)[b]
ALT (U/l)	32.0	(3.6)[a]	19.0	(2.6)[b]
ALP (U/l)	109	(8.4)[a]	23.2	(2.7)[b]
CK (U/l)	89.0	(3.4)[a]	197.9	(20.7)[b]
LD (U/l)	182.1	(7.1)[a]	683.6	(13.0)[b]
T3 (nmol/l)	2.62	(0.10)[a]	1.97	(0.05)[b]
T4 (nmol/l)	171.17	(28.31)[a]	101.67	(20.59)[b]

n = 40; figures in brackets = SE.
[a,b] Duncan's grouping; different letters within the same row indicate significantly different results (p<0.05). For abbreviations see Table 1.

balance,and increased glucose turnover and absorption (Kaneko 1989; Murray et al. 1993).

The significantly higher values of AST, ALT and ALP observed in extremely hot conditions compared with cold conditions are in accord with the observations of Georgie et al. (1973), Kataria et al. (1991) and Kataria and Bhatia (1991), who reported increased activities in summer in both cattle and camels, attributing it to increased heat adaptation. Soveri et al. (1992) reported that the decrease in serum ALP activity in mid-winter is due to cessation of growth. In contrast to these findings, Bengoumi et al. (1997) reported that season had no significant effect on serum AST, ALT and ALP activities. Thyroid hormones (T3 and T4) showed significant positive correlations with serum AST, ALT and ALP activities, corresponding to higher activity of thyroid gland in heat conditions and heat adaptation of the camel.

LD exhibited a significantly higher value in extreme cold than in hot conditions. These results are in agreement with the findings of Kataria and Bhatia (1991) in the camel, and with those of Roussel and Stallcup (1967) in bulls. The increase in LD and CK activities in cold conditions is due to greater activity of the camel in winter months. Thyroid hormones (T3 and T4) had a significant negative correlation with serum LD and CK activities, corresponding to lower activity of the thyroid gland, and greater muscular activity of the camel in winter months and cold stress.

The higher concentration of urea in winter months probably results from cold stress and protein catabolism. This result is in agreement with the findings of Soveri et al. (1992) in reindeer calves and those of Eldon et al. (1988) in dairy cows, but differs from Rowlands et al. (1979), also in dairy cows. Barakat and Abdel-Fattah (1971) reported that in camels, BUN is not influenced by season. The correlation between thyroid hormones and BUN revealed that T3 and T4 had a significant effect on reduction of BUN in heat stress during the summer months. Thyroid hormones are required for stimulation of urea cycle enzymes so that more urea is excreted (Murray et al. 1993).

The higher concentrations of sodium, potassium, calcium and inorganic phosphorus in winter probably result from higher concentrations of these elements in the water and diet. There were different reports in this respect; Barakat and Abdel-Fattah (1971) reported that in camels, calcium and inorganic phosphorus are influenced by season ($p<0.05$), whereas Balbuena et al. (1993) showed that in growing cattle, plasma inorganic phosphorus concentrations were normal in all seasons. In similar results to ours, Mehrotra and Gupta (1989) reported that in camels during January, when the temperature was lowest, sodium, potassium and inorganic phosphorus increased. This differs from the results of Rowlands et al. (1979) who reported that in dairy cows potassium was slightly higher in summer and autumn, and that inorganic phosphorus was highest in the autumn. Similarly, Eldon et al. (1988) showed that in dairy cows the mean values for calcium were highest in the autumn.

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