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Effect of Prolonged Heat Exposure on Serum Glutamic Oxaloacetic and Glutamic Pyruvic Transaminase Activities of Rats

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連續的 溫熱曝露가 흰쥐의 血淸 Glutamic Oxaloacetic Transaminase 및 Glutamic Pyruvic Transaminase의 活性에 미치는 影響

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摘 要

成熟한 Sprague-Dawley系의 雄性 흰쥐를 30±0.5°C에서 240時間 그리고 33±0.5°C에서 64時間 各各 溫熱曝露시켰으며, 溫熱曝露 期間中 여러 時間區에서 血淸 glutamic oxaloacetic transaminase (GOT)와 血淸 glutamic pyruvic transaminase (GPT)의 活性을 Reitman 및 Frankel (1957)의 方法에 依해서 Coleman-Model 295 E Spectrophotometer로서 各各 550 mμ에서 測定하였다. 23±1°C인 對照群에 比較하여 보면, 30±0.5°C 및 33±0.5°C에서 溫熱曝露된 흰쥐는 各各 血淸의 GOT 및 GPT의 活性이 有意性있게 上昇되었다. 서로 다른 高溫의 溫熱에 曝露된 흰쥐의 血淸 GOT 活性은 16 및 30時間 區間中에서 또한 64 및 72時間 區間中에서 各各 有意性있게 上昇되었다. 한편 30±0.5°C에서 72時間後에는 血淸 GOT 活性은 正常群으로 되돌아가는 傾向이 나타났다. 서로 다른 高溫의 溫熱로 曝露된 흰쥐의 血淸 GPT의 活性은 初期인 4時間區에서 有意性있게 上昇되었으며, 이어서 16時間區와 64 및 72時間 區間中에서 各各 上昇되었다. 한편 30±0.5°C에서는 114時間後에 약간 增加하는 傾向이 나타났다.

30±0.5°C와 33±0.5°C에서 各各 溫熱曝露된 흰쥐의 酵素活性을 比較하여 보면, 33±0.5°C에 曝露된 흰쥐의 血淸 GOT 및 血淸 GPT의 活性은 各各 16, 30 및 64時間區에서 有意性있게 높은 活性을 나타내었다.

이러한 結果로 미루어 보아 連續的 溫熱曝露는 非正常의 아미노基 轉移代謝를 招來하는 것으로 思料된다.

INTRODUTION

Of all the environmental factors influencing the physiology of organism, temperature probably has the most manifold effects. Temperature governs the speed and

limits of metabolic reaction; thus, it determines the limits of distributions, growth, and ecology of many organisms. Animal must respond to this influence by evolving mechanisms for resistance, adjustment, behavioral regulation or physiological control. Animals respond to changes in environmental temperature by conforming passively to the environment (Prosser and Brown, Jr., 1961). Usually this response involves acclimation of a continuous change in physiological organization in direct response to changes in temperature.

Glutamic oxaloacetic transaminase is a specific enzyme concerned with the transfer of the alpha animo nitrogen of aspartic acid to alpha-ketoglutaric acid, resulting in the synthesis of a new amino acid, glutamic acid, and a new alpha-keto-acid, oxaloacetic acid. This protein catalyst is widely distributed in animal tissues but its concentration or activity is greatest in heart muscle, skeletal muscle, brain, liver, and kidney in decreasing order (Cohen and Hekhius, 1941).

There is evidence that enzyme levels in serum may increase with many nonspecific physiological stresses, without obvious organic lesions, i. e., severe altitude hypoxia (Highman and Altland, 1960), muscular exercise (Altland and Highman, 1961; Halonen and Konttinen, 1962; Bedrak et al., 1964), vibration, noise and confinement (Freeman and Polis, 1959), exposure to ionizing radiation (Kessler et al., 1958; Albaum, 1960; Frederick et al., 1963; Almonte et al., 1964; Stevens and Berliner, 1964; and Nam and Chang, 1970), acute exposure to cold (Blair et al., 1961; Highman and Altland, 1962), and exposure to acute heat stress (Freeman and Polis, 1959; Bedrak et al., 1963; Bedrak, 1965). In addition, there are reports on the effect of heat exposure on serum protein component (Nam, 1963; Nam et al., 1967).

The present experiments were initiated in an effort to determine how prolonged heat exposure influences the activities of serum glutamic oxaloacetic transaminase (SGOT) and serum glutamic pyruvic transaminase (SGPT).

MATERIALS AND METHODS

Laboratory conditioned male Sprague-Dawley rats with body weight of 200~270 gm were used. Animals were randomly segregated into three groups. One group served as the control animals and were maintained at 23±1°C. The second group was continuously subjected to environmental temperature of 30±0.5°C for 240 hours and the third group to higher environmental temperature of 33±0.5°C for 64 hours.

They were kept in a daylight-illuminated animal room. A large incubator regulated by an electric thermostat at an average air temperature of 30±0.5°C or 33±0.5°C was used for temperature treatment of rats. The inlet and outlet of air heat chamber opened to protct the animal from hypoxia. No air current was allowed in the heat chamber except for natural connection. The relative humidity in the incu-

bator was from 60 to 65% during the experiment.

Blood samples were obtained with tubes from severed left saphenous vein. Serum was separated by centrifugation at 3,000 rpm for 15 minutes and kept in a refrigerator until determination of enzymatic activity. Haemolysed sera were rejected.

Serum glutamic oxaloacetic transaminase (SGOT) and serum glutamic pyruvic transaminase (SGPT) activities were determined at 505 mμ with a Coleman-Model 295 E spectrophotometer according to the procedure outlined by Reitman and Frankel (1957) utilizing commercial reagents supplied by the Sigma Chemical Company. The SGOT and SGPT activities were expressed as units per ml.

Statistical evaluation of the data was accomplished by calculating the mean activity and the standard error of the mean for each enzyme studied. Comparision of means was made by t-test (Croxton, 1953). All differences having a probability level of 0.05 or less were considered significant levels in the different environmental temperature. Average control values were 37.78 units/ml for SGOT and 22.46 units/ml for SGPT. With higher environmental temperature (33±0.5°), the heatexposed rats died after 64 hours.

The activities of SGOT and SGPT were altered by prolonged heat exposure in the different environmental temperature. In the present data, it should be noted

RESULTS

Table 1 and Fig. 1 show the SGOT levels, and Table 2 and Fig. 2 the SGPT

Table 1. Effects of environmental temperature on SGOT activity of rats

Group	Hours during heat exposure	No. of rats	Serum GOT activity (units/ml) level	
			Mean	Standard error
Control (23±1°C)	0	12	37.78	±0.88
	4	7	37.92	±0.93
	8	7	38.73	±0.59
	16	7	40.42	±0.53
	30	7	38.20	±1.78
High temperature (30±0.5°C)	48	7	37.80	±2.93
	64	7	38.50	±0.46
	72	7	43.20	±0.67
	144	7	38.34	±1.53
	240	7	35.40	±0.57
Control (23±1°C)	0	12	37.78	±0.88
	4	7	38.20	±1.34
	8	7	39.14	±1.09
	16	7	42.16	±1.56
Higher temperatue (33±0.5°C)	30	7	43.80	±1.05
	48	7	39.20	±2.58
	64	7	44.10	±1.06
	Died			

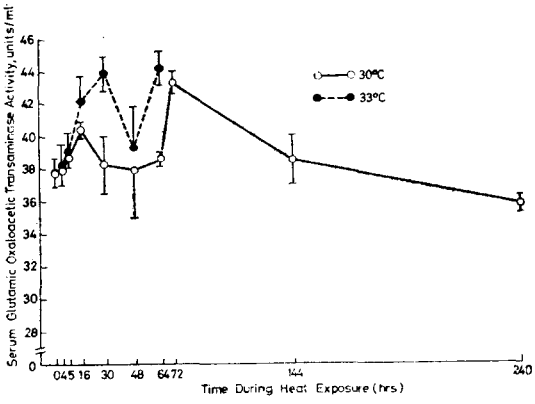

Fig. 1. Influence of environmental temperatures on serum GOT level of rats. Each point represents an average value for the number of rats given in Table 1 and the vertical bars indicate the standard error of the mean.

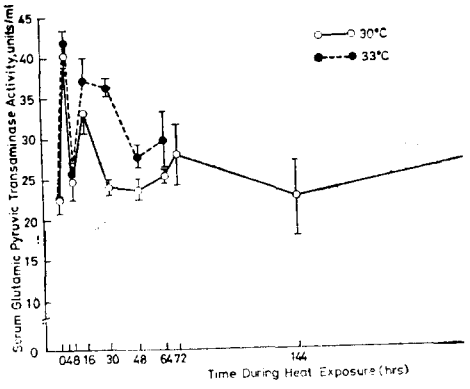

Fig. 2. Influence of environmental temperature on serum GPT level of rats. Each point represents an average value for the number of rats given in Table 2 and the vertical bars indicate the standard error of the mean.

that exposure of the rats to heat stress enhances the activities of SGOT ($p<0.05$) and SGPT ($p<0.05$) within a relatively short period.

It is clear from Table 1 and Fig. 1 that at $30\pm0.5°C$ the SGOT activity rose from 37.78 units to 40.42 at 16 hours and to 43.20 at 72 hours and thereafter returned to the normal during next 240 hours. At $33\pm0.5°C$, however, their SGOT activities increased from 37.78 units to 43.80 at 30 hours and 44.10 at 64 hours. As shown in Table 2 and Fig. 2, at $30\pm0.5°C$ SGPT activity rises from 22.46 units to 40.15 at 4 hours, to 33.20 at 16 hours, and to 27.90 at 72 hours and thereafter increased slowly during next 24 hours, while at $33\pm0.5°C$ from 22.46 units to 41.77 at 4 hours, to 37.04 at 16 hours, and to 29.60 at 64 hours.

Comparing the enzymatic activities of $30\pm0.5°C$ or $33\pm0.5°C$ heatexposed rats, it was revealed that activities of SGOT and SGPT were significantly higher in heat exposed rats at $33\pm0.5°C$ in 16, 30 and 64 hours, respectively. The heat induced elevation of SGOT and SGPT levels may be attributed mainly to the release of the enzymes from the cells following prolonged heat exposure. Thus, the variation observed in the transaminases could not be attributed to the state of acclimatization.

DISCUSSION

The present data demonstrate that the stress of temperature increased the levels of SGOT and SPGT enzymes in the serum of rats. In most case, the magnitude of change was higher in heat exposed rats at $33\pm0.5°C$ than at $30\pm0.5°C$.

When an animal is placed in a hot environment the heat receptors of the skin

Table 2. Effects of environmental temperature on SGPT activity of rats

Group	Hours during heat exposure	No. of rats	Serum GPT acitivity (units/ml) level	
			Mean	Standard error
Control (23±1°C)	0	12	22.46	±1.61
	4	7	40.15	±3.35
	8	7	24.90	±2.58
	16	7	33.20	±2.47
	30	7	24.00	±0.93
High temperature (30±0.5°C)	48	7	23.74	±1.30
	64	7	25.25	±0.78
	72	7	27.90	±3.78
	144	7	22.40	±4.60
	240	7	28.50	±0.64
Control (23±1°C)	0	12	22.46	±1.61
	4	7	41.77	±1.70
	8	7	25.50	±1.43
	16	7	37.04	±2.95
Higher temperature(33±0.5°C)	30	7	36.30	±1.10
	48	7	27.80	±1.46
	64	7	29.60	±3.75
	Died			

are stimulated, and reflex responses favoring dissipation of heat result. When cooling mechanism fails and body temperature rises, the O_2 consumption increases because of the direct cellular effect of heat and also the increased ventilation : possibly the increased metabolism may be part of the regulating mechanism since it is less in thyroidectomized and hypo pysectomized rats (Prosser and Brown, Jr., 1961). Heat death is due in large part cardiovascular failure. The tolerated temperatue is less with external than with internal warming; a man losses consciousness when heated externally to a rectal temperature of 38.6°C, yet in fever the temperature may go to 42°C and in excercise the body temperature may reach 40°C without harm (Webb and Veghte, 1958).

Fleischner and Sargent (1959) observed that rats acclimated to cold are more sensitive to heat than are warmacclimated rats, and the latter are more sensitive to cold. Acclimatization to heat is by lowered threshold for sweating, dilution of sweat, improved cardiovascular efficiency (in man); one genetic adaptation is tolerance of elevated body temperature (camel) (Prosser and Brown, Jr., 1961).

One of the explanations suggested for the elevated level of enzymes in the blood serum of animals exposed to a physiological stress is a general increase in cellular permeability (Zierler, 1956; Freeman and Polis, 1959; Altland and Highman, 1961; Holonen and Konittine, 1962; Highman and Altland, 1962). It has been reported that glutamic oxaloacetic and glutamic pyruvic transaminase levels in the various animals following X or gamma-irradiation increased after the exposure (Kessler et

al., 1958; Albaum, 1960; Frederick et al., 1963; Almonte et al., 1964; Stevens and Berliner, 1964; Nam and Chang, 1970). Bedrak (1965) reported that enhanced activities of GOT and GPT were observed in dogs exposed to acute heat stress (47°C~56°C) at 30 and 120 minutes. The albumin/globulin ratio and the level of the total serum protein were significantly lower in mice and pigeons subjected to the heat stress as compared to the control (Nam, 1963; Nam et al., 1967).

An additional factor that may participate in regulating serum enzyme level is moderate dehyration. Yet in the present study, elevated enzyme activities persisted even after water loss had been virtually replaced by drinking during the recovery period. Since the water deficit is recovered by dogs within a relatively short period (Dill et al., 1933) and a constant level of plasma protein is maintained (Dill, 1938), indicating that plasma volume remains unchanged (Schmidt-Nielsen, 1964), the effect of moderate dehyration on the activity of the various serum enzymes may be questioned.

Hydrocortisone is known to stimulate the activity of hepatic glutamic pyruvic transaminase (Rosen et al., 1958; Rosen et al., 1959). Rosen et al. (1959) observed that deoxycorticosterone acetate lowered the activity of hepatic glutamic pyruvic transaminase; adrenaline and noradrenaline greatly stimulated activity of serum alkaline phosphatase and transaminase (Highman et al., 1959). In secretion of adrenaline metabolites in the urine of acclimatized as compared with unacclimatized subject (Sulman et al.,1962), one may speculate that altered adrenaline secretion, and possibly mineralocorticosteroids, are at least partly responsible for the observed changes in the activity of the various enzyme systems in acclimatization.

Although increased SGOT and SGPT activities may qualitatively indicate the tissue damage inflicted by prolonged heat exposure, survival of the animal appears to depend on ability to overcome and repair the resultant damage. The immediate increase in SGOT and SGPT levels following heat exposure of rats may be due to the liberation of enzymes from tissues into blood stream. Therefore the rise in SGOT and SGPT activities may represent cell damage.

The results obtained in this study support the concept that the prolonged heat exposed rat has the abnormal metabolism of transamination.

SUMMARY

Sera from male Spague-Dawley rats, exposed to 30±0.5°C for 240 hours or 33±0.5°C for 64 hours, were assayed for the activities of serum glutamic oxaloacetic transaminase (SGOT) and serum glutamic pyruvic transaminase (SGPT) at various time during the heat exposure.

1. When compared to control animals maintained at 23±1°C, the animals exposed to 30±0.5°C or 33±0.5°C showed a significant increase in SGOT and SGPT

activities,

2. The SGOT activity incressed at 16 and 72 hours after the exposure to 30°C, and at 30 and 64 hours after the exposure to 33°C. After 72 hours, the activity returned to the initial value in case of 30°C exposure.

3. The SGPT activity increased significantly as early as 4 hours after the exposure to 30°C or 33°C. It was also high at 16 hours after the exposure. The activity was also high at 72 hours and at 64 hours after the exposure to 30°C and 33°C respectively. After 144 hours, SGPT level increased slightly in the case of 30°C exposure.

4. The activities of SGOT and SGPT were significantly higher in rats exposed to 33°C at 16, 30, and 64 hours than those exposed to 30°C.

5. It may be inferred from above data that the prolonged heat exposed rat has the abnormal metabolism of transamination.

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