WATER LOSS UNDER HOT AMBIENT TEMPERATURES

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Male albino rats were exposed to hot ambient temperature (40°, 42° and 44°C) for different durations of time upto a maximum of 3 hours. It was observed that there was a rapid loss in body weight accompanied by considerable increase in body temperature of the animals during the first hour of exposure. Thereafter the rate of body weight loss and increase in body temperature were slow till the end of observation period. Intolerance to heat appears to be more correlated with critical body temperature rather than the extent of dehydration.

Heat dissipation in homeothermic animals is achieved essentially by respiratory cooling through panting, salivation and peripheral vascular dilatation with variable contribution from insensible and sensible (apocrine) cutaneous evaporation. Dehydration reduces heat tolerance of men[1].

Dehydration reduces sweat secretion even if thermoregulation fails and body temperature rises and sweat rates of dehydrated men could be increased within an hour by fluid ingestion or decreased by fluid abstention[2]. It was also observed that sweat rates during dehydration and heat stress were reduced before body weight loss exceeded 1-2% of initial body weight in resting man[3]. Sweat rates were reduced during the first hour of heat exposure before loss of 1% of their body weight[4]. Cattle dribbled large volumes of saliva to provide further evaporative heat loss when exposed to extreme hot conditions[5]. Various workers[6,7] have determined the total evaporative water loss by the change in body weight. In the present study, unadapted male albino rats were exposed to 40°, 42° and 44°C, a constant relative humidity (RH) 48-50% and an air speed of 0·3 m/sec. to study the extent of water loss and its correlation to body temperature.

MATERIALS AND METHODS

Adult male Sprague Dawley rats of body weight between 110 to 120 gms were used. Rats were given a standard diet[8] and allowed free access to water except on the day of experiment when food and water were withheld since morning. Rats were exposed to higher ambient temperatures by keeping them in a hot chamber at increasing temperatures (40°, 42° and 44°C) with a constant relative humidity (RH) of 48–50% and an airflow of 0·3 m/sec. for different durations of time. Control rats were maintained at room temperature, 27°-28°C. For each experiment, fresh group of rats were subjected to high ambient temperature for 1·0, 1·5, 2·0, 2·5 and 3·0 hr respectively, to avoid chances of adaptation. Rats were weighed before and immediately after exposure to high ambient temperatures and their loss in body weight was taken as due to their loss of body water. Skin temperature was measured with standard thermocouple instrument and rectal temperature by a standardised clinical thermometer.

RESULTS AND DISCUSSION

Tables 1, 2 and 3 respectively present the data on body weight loss, body temperature and survival rates in rats exposed to higher ambient temperatures (40°, 42° and 44°C) for different durations of time upto a maximum period of 3 hours.

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TABLE 1

LOSS IN BODY WEIGHT OF RATS EXPRESSED AS PERCENTAGE OF RESPECTIVE INITIAL BODY WEIGHT AT DIFFERENT TIME INTERVALS OF EXPOSURE TO VARYING AMBIENT TEMPERATURE

Ambient temperature (°C)	Exposure time (hr) 1·0	1·5	2·0	2·5	3·0
40°	3·5±0·3	4·7±0·3	6·0 ± 0·3	7·0±0·4	7·8±0·5
42°	4·7±0·5	6·0±0·2	7·3 ± 0·3	8·2±0·6	9·0±0·5x
44°	5·0±0·3	6·7±0·3	8·5*±0·6	9·5±0·4+	—

The results are mean value ± S. E. of 15 different experiments except in cases of x, * & + where the results are for 13, 12 and 10 respectively.

The significance of linearity of the relationship of percentage of weight loss versus length of exposure at given temperature (40°, 42° and 44°C) was tested by analysis of variance and was found significant at less than the 1% level.

TABLE 2

RECTAL (Tr) AND SKIN TEMPERATURE (Ts) OF RATS EXPOSED FOR VARYING LENGTH OF TIME AT DIFFERENT AMBIENT TEMPERATURES ARE EXPRESSED IN °C

Ambient temp. (°C)	Rectal (Tr) & Skin (Ts) Temperature	Duration of exposure (hr) 1·0	1·5	2·0	2·5	3·0
28—29°(Control)	Tr	36·3°±1·3	36·3°±1·3	36·3°±1·3	36·3°±1·3	36·3°±1·3
	Ts	35·4°±0·4	35·4°±0·4	35·4°±0·4	35·4°±0·4	35·4°±0·4
40°	Tr	38·3°±1·4	38·5°±1·0	38·6°±1·8	39·0°±1·4	39·2°±0·7
	Ts	35·8°±0·6	35·8°±0·6	36·0°±0·5	36·2°±0·5	36·4°±0·7
42°	Tr	39·1°±1·3	39·3°±0·9	39·4°±0·6	39·7°±0·6	40·1°±0·6x
	Ts	36·3°±0·4	36·4°±0·6	36·5°±0·6	36·9°±0·8	37·2°±0·7
44°	Tr	39·3°±0·6	39·6°±0·6	40·1°±0·5*	40·6°±0·8+	—
	Ts	36·6°±0·6	36·8°±0·7	37·1°±0·8	37·5°±0·7	—

The results are mean value ± S. D. of 15 different rats except in cases of x, * & + where the results are for 13, 12 and 10 respectively.

$P < 0{\cdot}001$ in each of the experimental results as compared to the control.

TABLE 3

EFFECTS OF VARIATIONS IN THE AMBIENT TEMPERATURE ON THE SURVIVAL RATE OF RATS

Ambient temperature (°C)	Exposure time (hr)	Body weight loss (%)	Rectal temperature (°C)	Survival (%)
	2	7·3	39·4°±0·6	100
42°	2·5	8·2	39·7°±0·6	100
	3	9·0	40·1°±0·6	86
	2	8·5	40·1°±0·5	80
44°	2·5	9·5	40·6°±0·8	66
	3	—	41·1°±0·6	<50

The results are mean value ± S.D. of 15 different rats. $P < 0{\cdot}001$.

The animals had developed considerable dehydration in all heat exposure groups as indicated by weight loss at the end of first hour of exposure. However, the extent of dehydration was comparatively more with the increase in ambient temperature during the first hour of exposure. After 1·5 hr of exposure, the rates of dehydration considerably decreased in all groups. The group exposed to 44°C had higher rate of dehydration in the second hour as compared to the other two experimental groups where the rates of dehydration were practically the same. Rectal temperature increased considerably in all groups at the end of the first hour of exposure, the rise being more with the increase of exposure temperature. After 1·5 hr of exposure, the rates of increase in body temperature fell sharply in all groups. Skin temperature showed a somewhat similar trend. This is rather unexpected. If the extent of dehydration were associated with temperature intolerance then the decrease in the rate of dehydration in all cases of heat exposures after first hour should have been accompanied by high rates of increase in rectal temperature. In the present case, rectal temperature rise was more in the first hour when rates of dehydration were high and the rate of increase in rectal temperature fell down sharply in all cases of heat exposures after 1·5 hr onwards when the rates of dehydration also fell down. These findings show that in these animals the extent of dehydration is not directly connected to heat intolerance.

There was no mortality in rats exposed to 40°C. Ra's exposed to 42°C had no casualty upto 2·5 hr of exposure, after 3 hr of exposure, survival rate was 86%. Rats exposed to 44°C, had 80% mortality within 2 hr of exposure. This increased very much beyond 2 hr. It may be noted that extents of dehydration were practically the same in 42°C exposure group at the end of 2·5 hr and in 44°C exposure group at the end of 2 hr while survival rates were very much different. This again shows that extent of dehydration is not directly related to heat intolerance in these animals. Mortality was first noted in 42°C exposure group at the end of 2 hr when rectal and skin temperature were practically the same in the two groups. Thus approximately 40°C rectal temperature accompanied by 37·1°C skin temperature seems to be critical for heat intolerance in these animals. It is concluded that in albino rats attainment of critical body temperature is by far the more important factor for heat intolerance, where as extent of dehydration is not directly related to it.

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