RELATIONSHIP BETWEEN CHANGES IN RESPIRATION AT A HIGH ENVIRONMENTAL TEMPERATURE AND THE POSITION OF THE ANIMAL

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Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 54, No. 10,
pp. 60-63, October, 1962
Original article submitted April 30, 1961

The effect of hyperthermia on respiration has been studied in many investigations on animals fixed to the bench, although this procedure in itself necessarily leads to some slowing of respiration [3]. The object of this study was to discover to what extent the animal's position affects the respiration rate when the external environmental temperature is raised.

EXPERIMENTAL METHOD

Two series of experiments were conducted on 17 rabbits. In the first series eight animals were warmed to a temperature of 43-45°. The respiration was recorded with the rabbit in a sitting position. In the second series the respiration was recorded in the same rabbits at a temperature of 39-41° in the sitting and lying positions (tied to the bench on their back). In the latter case the rectal temperature was also measured by means of a low-inertia electrical thermometer (ETM-3b). For the rest of the time the animals sat in the hot chamber at any position they chose.

The results were analyzed by statistical methods. The degree of the individual differences was characterized by the variation coefficient, indicating the value of the mean square deviation as a percentage of the arithmetical mean.

EXPERIMENTAL RESULTS

In the first series of experiments the respiration rate of the rabbits in a sitting position before warming was 76 ± 11. In the hot chamber the rate rose steadily to 344 ± 32 after 45 min (Table 1). The variation coefficient of the increase in the respiration rate followed a regular pattern; it was maximal after warming for 15 min, and then fell throughout the rest of the experiment.

TABLE 1. Effect of Warming to 43-45° on the Respiration of Freely Sitting Rabbits

Criteria investigated	Statistical criterion	Before warming (18-20°)	During heating			
			time of heating in munutes			
			15	30	45	60
Respiration rate per minute	M ± m	76 ± 11	168 ± 33	290 ± 26	344 ± 32	328 ± 26
	V ± mv	38 ± 12	51 ± 17	23 ± 6	25 ± 7	21 ± 6
Increase in respiration rate	M ± m		92 ± 42	213 ± 33	268 ± 24	252 ± 21
	V ± mv		120 ± 63	41 ± 13	24 ± 7	22 ± 6

Note: M ± m—arithmetical mean and limits of error; V ± m—variation coefficient and limits of error.

These results show that the respiration rate rose sharply in the unimmobilized rabbits. The increase in rate was much greater than in the fixed animals which we studied previously [5, 6], but the experimental conditions, of course, were not identical. The conditions of the next series of experiments were such that the respiration of each animal was recorded at the corresponding times, firstly, when the animal was free to move, and secondly, in a fixed position.

TABLE 2. Effect of Heating to 40° on the Respiration of Rabbits Depending on the Method of Recording

Position of animal	Statistical criterion	Respiration rate per minute			Increase in respiration rate	
		before warming (20-22°)	during warming		during warming	
			time of warming in minutes			
			30	70	30	70
Free	M ± m	162 ± 26	315 ± 32	348 ± 14	153 ± 17	186 ± 26
	V ± mv	44 ± 13	29 ± 8	11 ± 3	31 ± 9	40 ± 12
Fixed	M ± m	102 ± 15	280 ± 36	234 ± 27	178 ± 26	131 ± 29
	V ± mv	42 ± 12	36 ± 9	32 ± 9	42 ± 12	62 ± 21
		body temperature			increase in body temperature	
	M ± m	38.67 ± 0.22	40.01 ± 0.22	41.16 ± 0.19	1.34 ± 0.11	2.49 ± 0.12
	V ± mv	1.65 ± 0.41	1.55 ± 0.39	1.29 ± 0.32	22 ± 6	14 ± 3

Legend as in Table 1.

Warming caused an increase in the respiration rate of the animal in both positions (Table 2). In the sitting position, the initial respiration rate averaged 162 per minute, and after 30 min it reached 315, and 348 at the end of warming. Fixation of the rabbits led to a slowing of respiration whether the environmental temperature was normal or high. The respiration rate in the fixed position before warming was 102 per minute on the average, at the 30th min 280, and at the 70th min 234.

The mean value of the increase in the respiration rate was greater at the 30th min for the rabbits in the fixed position, and at the 70th min for those in the sitting position, although these differences were within the limits of error.

At a high temperature a significant decrease was observed in the individual differences in the respiration rate, i.e., the variation coefficient was lowered. On the other hand, the individual differences in the increase in the respiration rate increased slightly towards the end of warming. The variation coefficients of the body temperature and of its increase fell during the experiment, although their changes were within the limits of error.

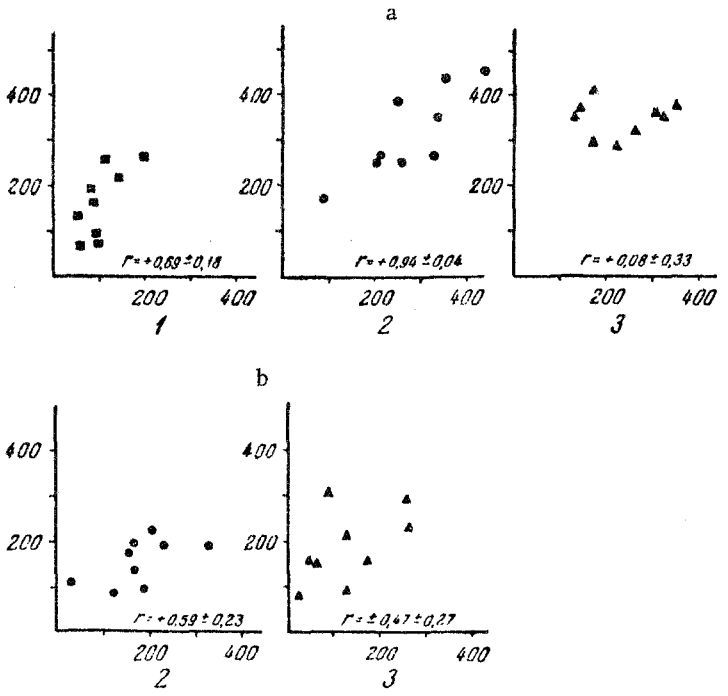
The results of the experiments are illustrated in the figure, each point on which is the mean of three measurements in the same rabbit. If the respiration rate of an animal was high in the free state, it remained relatively high after fixation. Correspondingly, in the remaining animals, the respiration rate was lower in both the free and fixed positions. These relationships were defined more accurately by the coefficient of correlation (r), which had a high positive value (see figure).

These experiments showed that hyperthermia increases the respiration rate to a greater degree than pathological factors such as injury to the lungs with hot water [2, 3] or the introduction of turpentine into the subarachnoid space, causing pneumonia [10].

According to our findings, hyperthermic tachypnea bears little relationship to the position of the rabbits. Moreover, a fairly high coefficient of correlation is present between the respiration rates (and their increases) of the animals in different positions. Fixation of the rabbits to the bench on their back causes a marked slowing of respiration whether the external environmental temperature is normal or high.

When the environmental temperature was high, a regular decrease was observed in the variation coefficients of the respiration rate and in the increase in body temperature. A reduction in the individual differences was also

found in experiments in which dogs were exposed to high environmental temperatures [7, 8] and to severe anoxia [1]. A common mechanism evidently lies at the basis of these phenomena. In all the cases described, the demands made on the animal organism were considerable, and must have formed a dominant focus of excitation in the brain. This may also account for the fact that the individual differences were not so marked.



Rate (a) and increase in the rate (b) of respiration before warming (1) and at the 30th (2) and 70th (3) minute of warming. Along the axis of abscissas – results obtained with the animals in a fixed position; along the axis of ordinates – sitting.

It may also be suggested that in such extreme conditions, the role of unconditioned reflexes in the regulation of the functions undergoes a relative increase. This may be one cause of the decrease in the individual differences in the manifestation of the physiological reactions, for the differences in the conditioned-reflex reactions in different animals of the same species are evidently more marked than the differences in the unconditioned-reflex conditions .

SUMMARY

There was a positive correlation between the frequency and acceleration of respiration in fixed and freely sitting rabbits at an outside temperature of 40-45°C. Respiratory rhythm was lowered in rabbits tied to a stand with their back downwards, this occurring both at usual and high temperatures. Under the effect of high temperature the variational coefficients of respiratory rhythm decreased while body temperature was seen to rise. Reduced individual differences of some functional indices are, evidently, characteristic of conditions that tend to increase requiremen for the body.

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