EFFECT OF DYNAMIC OVERLOADING ON FUNCTIONS OF THE ENDOCRINE GLANDS IN DOGS OF DIFFERENT AGES

V. A. Pegel', S. M. Ksents, and S. A. Khoreva

UDC 612.43-06:612.766.1

A biochemical analysis was made of blood samples taken from dogs (aged 6-9 months, 2-5 years, and over 8 years) before physical exertion, during running on a treadmill (11 km/h), and in the period after work. It was found that dynamic loading induced an increase in the blood concentration of 11-hydroxycorticosteroids (11-HCS), adrenalin-like substances, sugar, and lactic acid in the dogs aged 2-5 years, but a decrease in the 11-HCS concentration, delay in the liberation of adrenalin-like substances, and hypoglycemia in the older dogs. The young dogs occupied an intermediate position between the old and middle-aged animals.

No reports could be found in the literature of investigations into the functional relationships between several endocrine glands actually during the performance of physical work and taking into account the age of the animal. Nevertheless it is during the period of work that the ontogenetic evolution of adaptive mechanisms is most clearly revealed and the changes in physiological functions which take place and which are most frequently observed by investigators in the period after work are formed.

In the investigation described below, changes were observed in a number of blood indices characterizing the state of several endocrine glands were studied in dogs of different ages before, during, and after running on a treadmill.

EXPERIMENTAL METHOD AND RESULTS

The method of taking blood (at rest, during running on a treadmill at a speed of 11 km/h, and in the recovery period) and methods of its analysis were described previously [3]. Altogether 59 experiments (30 control and 29 with dynamic loading) were carried out on 17 dogs of both sexes, 7 aged 6-9 months, 5 aged 2-5 years, and 5 over 8 years old.

In the control experiments, in which the dogs stood for 2 h in a frame, the changes in the indices studied were negligible. However, in the young dogs a significantly higher blood concentration of 11-hydroxycorticosteroids (11-HCS) was observed than in the animals aged 2-5 years ($P < 0.05$) and the concentration of protein-bound iodine also was significantly higher than in the old dogs ($P < 0.05$).

After the first minutes of performance of work and until the end of the recovery period, the 11-HCS concentration in the arterial blood of the young and old dogs was significantly lowered by comparison with the initial level (Table 1). In the animals aged 2-5 years, on the other hand, the level of glucocorticoids rose at the beginning of the work, but returned to its initial level in the subsequent minutes of running, and remained at that level throughout the recovery period. According to Viru [1], a decrease in the corticosteriod concentration in the blood is one of the features of acute fatigue; if this view is accepted, it must be assumed that in dogs aged 2-5 years the changes in the corticosteroid concentration both during work and in the recovery period were more adequate than in the young and old dogs.

Department of Physiology of Man and Animals, Tomsk University. (Presented by Academician of the Academy of Medical Sciences of the USSR N. A. Yudaev.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 74, No. 8, pp. 6-9, August, 1972. Original article submitted December 23, 1971.

TABLE 1. Changes in Concentrations of 11-HCS, Protein-Bound Iodine, Adrenaline-Like Substances, Sodium, and Potassium, in the Sodium/Potassium Ratio, and Concentrations of Sugar and Lactic Acid in Arterial Blood of Dogs of Different Ages under the Influence of Dynamic Loading (M ± m)

Index	Dogs aged 6-9 months					Dogs aged 2-5 years		
	background	dynamic loading		recovery		background	dynamic loading	
	10 min	30 min	40 min	50 min	120 min	10 min	30 min	40 min
11-HCS (in μg %)	7,58±0,09	6,10±0,78	5,67±0,72 P <0,025	5,67±0,83 <0,05	3,85±0,45 <0,001	5,82±0,69	7,02±0,68 <0,025	5,78±0,74
Protein-bound iodine (in μg%)	7,07±1,08	8,45±0,14 P <0,01	8,07±1,02	7,95±0,97	8,39±0,56 <0,025	6,02±1,02	6,06±0,56	6,77±0,60
Adrenalin-like substances (in μg%)	8,05±1,09	12,54±1,90 P <0,05	10,89±2,20	8,92±2,30	9,54±1,91	9,10±1,19	15,57±2,41 <0,025	7,30±1,50
Sodium (in μeq/liter)	114±5,85	107±5,05	105±3,96 P <0,025	107±3,23 <0,05	99±4,87 <0,01	111±7,65	104±4,94	96±5,37 <0,02
Potassium (in μeq/liter)	3,70±0,97	4,60±0,28 P <0,025	4,66±0,42 <0,025	4,24±0,13 <0,001	3,86±0,13	4,07±0,31	4,63±0,28	4,79±0,32 <0,01
Sodium/potassium ratio	31,4±2,10	23,1±1,99 P <0,01	24,1±2,65 <0,01	25,9±1,17 <0,001	26,2±1,77 <0,05	28,4±2,52	23,8±1,84 <0,05	20,8±2,02 <0,01
Sugar (in mg%)	83,5±3,40	86,4±3,71	91,5±6,60	84,8±4,72	96,4±7,88	78,9±5,25	84,1±4,96	86,9±4,94
Lactic acid (in mg %)	7,61±1,89	11,74±2,22	12,30±2,04 <0,05	10,64±1,51 <0,05	17,11±1,50 <0,001	7,41±1,47	12,17±1,59 <0,025	11,83±0,84 <0,001

TABLE 1 (cont'd)

Index	Dogs aged 2-5 years		Dogs over 8 years old				
	recovery		background	dynamic loading		recovery	
	50 min	120 min	10 min	30 min	40 min	50 min	120 min
11-HCS (in μg %)	5,88±0,44	4,88±0,69	7,58±1,68	4,45±1,42 P <0,05	4,52±1,72	4,00±1,93	3,63±1,83
Protein-bound iodine (in μg%)	8,18±0,47 P <0,001	6,61±0,68	4,95±0,66	5,32±0,57	4,48±0,43	5,63±0,35 <0,02	5,40±0,22
Adrenalin-like substances (in μg%)	8,97±1,42	11,04±0,98 P <0,05	4,00±1,27	5,82±1,19	7,94±0,96 <0,001	7,42±1,50 <0,05	7,83±1,17 <0,025
Sodium (in μeq/liter)	99±5,18 P <0,05	99±4,74 <0,05	108±7,71	102±6,00	95±6,81	95±6,81	99±19,51
Potassium (in μeq/liter)	4,35±0,44	3,84±0,30	3,38±0,3	4,13±0,26 <0,05	4,62±0,26 <0,01	4,10±0,27 <0,05	4,35±0,27 <0,01
Sodium/potassium ratio	23,1±1,46 P <0,025	26,4±1,09	33,9±4,04	26,3±3,46	21,0±2,66 <0,001	27,0±4,26	24,8±3,91 <0,05
Sugar (in mg%)	86,9±4,04 P <0,05	87,1±4,25	89,3±6,83	77,7±4,15 <0,025	71,7±7,75 <0,05	81,8±9,73	85,8±4,69
Lactic acid (in mg%)	10,83±1,51 <0,05	11,94±1,73 <0,025	10,3±0,69	10,9±1,61	9,4±1,39	14,1±1,66 <0,05	13,7±1,38 <0,01

Note: In all series of experiments, P was calculated relative to initial value.

Significant differences in the concentration of protein bound iodine compared with the original level were found in the older animals only in the period after work, but in the young animals during work also.

The blood concentration of adrenalin-like substances was increased during work, but in the old dogs their concentration became significantly higher than at rest only at the end of the period of running, while in the animals of the other two age groups it was significantly higher after running for only 10 min. At the beginning of strenuous muscular activity a marked hypoglycemia was observed in the old animals. In the young dogs and those aged 2-5 years, on the other hand, the increase in the blood concentration of sympathins was not accompanied by any change in the blood sugar.

Characteristically, the lactic acid concentration in the young animals and in the middle-aged dogs was significantly increased during running, whereas in the old dogs it was virtually unchanged. It may be that in old dogs the discharge of lactic acid into the blood stream during work was delayed because of the insufficient liberation of sympathins, and the lactic acid was utilized during hypoglycemia in the muscles as an energy-yielding material [4].

The decrease in the sodium/potassium ratio, in whose dynamics no age differences were found, may be evidence of depressed mineralocorticoid function of the adrenals [2]. The possibility cannot be ruled out that changes in the sodium and potassium concentrations in the blood during work may depend on the level of secretion of sympathins and of pituitary hormones.

Stimulation of corticosteroid and sympathico-adrenal activity and a constant level of the blood sugar were thus observed in middle-aged animals during running, while after exertion there was an increase in the blood concentration of protein-bound iodine. In the old dogs strenuous running induced a decrease in the corticosteroid concentration, hypoglycemia, and delay in the discharge of adrenalin-like substances into the blood. In the young animals the changes in the concentration of adrenalin-like substances, sugar, and lactic acid were similar in character to those in the dogs aged 2-5 years, while the changes in the glucocorticoid concentration were the same as those in the old dogs.

These results suggest that age is an important factor determining the dynamics of interaction between the functions of the endocrine glands during sustained muscular activity.

LITERATURE CITED

1. A. A. Viru, Teor. i Prakt. Fiz. Kul'tury, No. 8, 50 (1966).
2. A. L. Myasnikov and V. V. Men'shikov, Publications on New Apparatus and Techniques (First Moscow Medical Institute) [in Russian], No. 2, Moscow (1963), p. 5.
3. V. A. Pegel', S. M. Ksents, and S. A. Khoreva, Fiziol. Zh. SSSR, No. 11, 1586 (1970).
4. G. Von Wittke and M. Bohn, Z. Biol., 111, 271 (1959).