CORRELATIONS BETWEEN THE STATE OF THE SYMPATHICO-ADRENAL AND PITUITARY-ADRENAL SYSTEMS AND IN THE INSULIN LEVEL IN HORSES IN DIFFERENT SITUATIONS

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The blood levels of adrenalin, noradrenalin, ACTH, cortisol, andinsulin and the urinary excretion of catecholamines were investigated in horses after physical exertion and exposure to emotional situations. The highest degree of activation of the sympathico-adrenal system (SAS) and the pituitary-adrenocortical system (PACS), accompanied by a fall in the insulin level, was observed after training. A familiar emotional situation (the noise of the racetrack) activated both components of SAS and the PACS. An unfamiliar emotional situation (electronic music) evoked a distinct adrenal response. Correlation analysis showed that the initial background level predetermines future activation of the systems under the influence of powerful stimuli. Reciprocal relations between the hormonal and mediator components of SAS in the background state are converted into coordinated activation during training. Activity of one component of SAS regulates the degree of activation of the other component. Cross-correlation was found between activity of SAS and PACS and also between the insulin and catecholamine levels during exposure to physical and emotional influences.

KEY WORDS: insulin; sympathico-adrenal system; pituitary-adrenal system.

The functional state of the body in any stress situation and, in particular, during physical and emotional loads, depends on interhormonal relations. An important role in the formation of adaptive measurements in the response to these loads is played by the sympathico-adrenal system (SAS) and the pituitary-adrenocortical system (PACS), as well as the insular apparatus [1, 2, 5]. It was decided to analyze the correlation between indices affecting the activity of these systems during physical and emotional stress. The horse was chosen as the test object, because muscular activity is a natural factor for this animal, making unnecessary any artificial selection of loads to which laboratory animals must be exposed in experiments. The high emotional reactivity of the horse enables the effect of the emotional component and the associated biochemical changes to be easily distinguished. The blood adrenalin, noradrenalin, ACTH, cortisol, and insulin levels and the urinary excretion of catecholamines were investigated and correlation between these indices studied in horses after physical exertion and exposure to three types of emotional situation.

EXPERIMENTAL METHOD

A group of thoroughbred racing horses was studied. The model of physical exertion consisted of training exercises, which were stereotyped for all animals and lasted 45 min. Three situations were used to study the influence of emotional factors. One was saddling, which precedes any physical exertion and signified the beginning of work for the animal. The other two situations were reproduced under experimental conditions. Over a period of 40 min each horse listened to a tape recording of the noise of a racecourse or of the sounds of electronic music. The noise of the racetrack, familar to the animals, can be regarded as a signal of the beginning of a routine series of jumps. Electronic music, consisting of unfamiliar and harsh combinations of sounds, was something which the horses had never heard before.

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TABLE 1. Blood Adrenalin, Noradrenalin, ACTH, Cortisol and Insulin Levels in Horses after Training and Exposure to Sounds

Period of investigation	Number of investigations	Adrenalin, ng/ml	Noradrenalin, ng/ml	ACTH, ng/ml	Cortisol, ng/ml	Insulin, milliunits/ml
			Training			
Background	22	1,02±0,10	0,39±0,12	31,4±4,7	53,3±5,4	15,0±1,0
After 50 min	22	0,99±0,06	0,34±0,07	69,8±14,7*	118,1±8,8*	12,7±0,9*
			Noise of racetrack			
Background	10	1,22±0,26	0,33±0,11	26,9±5,5	46,2±7,3	16,8±1,0
After 10 min	10	1,20±0,28	0,70±0,14*	42,8±8,7	65,2±10,1	17,2±2,8
20 min	10	—	—	43,6±8,7	67,3±12,6	18,4±3,5
40 min	10	0,67±0,08*	0,83±0,33	43,1±9,9	66,0±7,4	20,1±2,9
			Electronic music			
Background	12	0,85±0,16	0,41±0,19	35,2±6,7	59,2±7,7	14,0±1,4
After 10 min	12	0,90±0,13	0,35±0,09	46,7±10,5	74,0±14,7	16,3±1,4
20 min	12	—	—	46,0±10,6	61,2±6,5	14,3±0,9
40 min	12	1,25±0,16*	0,32±0,21	46,6±9,5	70,3±12,2	17,6±2,4

*Difference statistically significant compared with background.

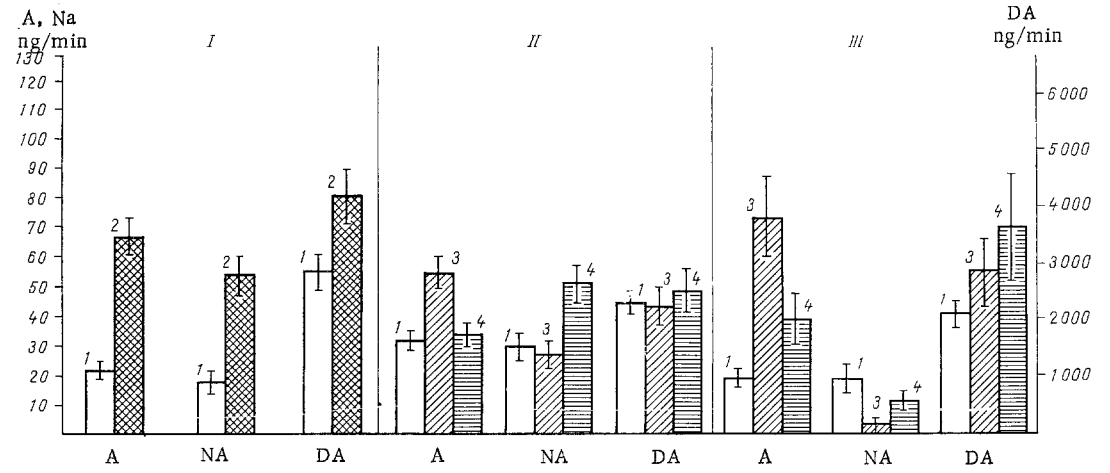

Fig. 1. Effect of training and acoustic stimulation on urinary catecholamine excretion: 1) before exposure; 2) after training; 3) 20 min after acoustic stimulation; 4) 40 min after acoustic stimulation. A) Adrenalin; NA) noradrenalin; DA) dopamine; I) training; II) electronic music; III) noise of racetrack.

Blood and urine were collected by catheters. The catecholamine levels were determined by fluorometric methods [6, 7]. The remaining hormones were studied by radioimmunologic methods, using kits from the firm "Sorin" (France) for ACTH and cortisol and the "Dia-gnost" kit (West Germany) for insulin.

EXPERIMENTAL RESULTS

Comparison of the results obtained during training exercises with the background data (Table 1; Fig. 1) showed marked activation of SAS and PACS, as reflected in an increase in the urinary excretion of adrenalin and noradrenalin and a marked rise in the blood ACTH and cortisol levels. The serum insulin concentration was lowered. A combination of a lowered insulin level and a raised catecholamine and corticosteroid level can be regarded as a regulatory mechanism exhibited during physical exertion and leading to increased formation of the energy-providing substrate, glucose, and its supply to the tissues.

Saddling led to a rise in the blood adrenalin concentration (from 0.42 ± 0.48 to 0.68-0.04 ng/ml). The other indices were unchanged. The noise of the racetrack, familiar to the horses and preparing them for the beginning of jumping, not only activated the adrenal cortex, as shown by an increase in the adrenalin excretion 20 min after listening to the recording, but also caused increased secretion of noradrenalin into the blood stream after 10 min. Addition of the results obtained 10, 20, and 40 min after stimulation showed a statistically significant increase in the blood ACTH and cortisol levels from 26.9 ± 5.9 to 43.2 ± 4.6 ng/ml and from 46.2 ± 7.3 to 66.2 ± 5.8 ng/ml respectively, evidence of activation of the PACS. Electronic music evoked a sensation of fear in the animals and led to increased secretion of the alarm hormone, adrenalin, into the blood stream at the

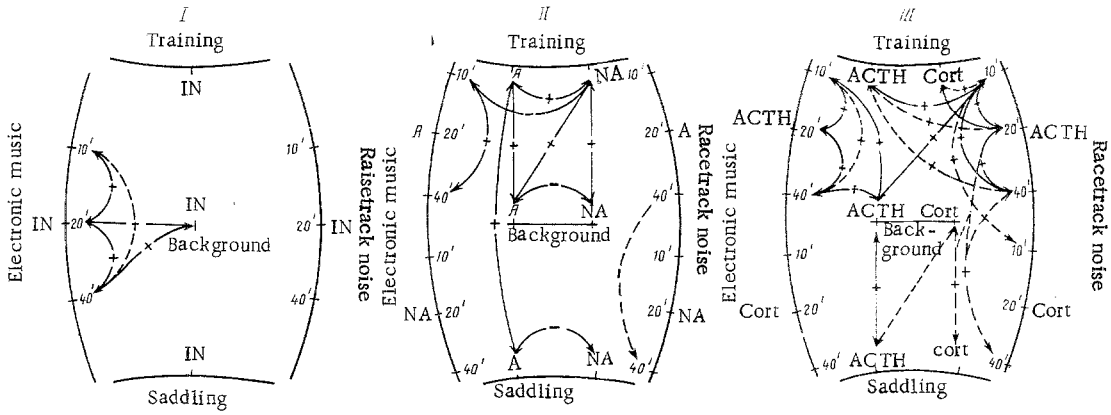

Fig. 2. Cross-correlations between indices of SAS, PACS, and blood insulin activity. I) Blood insulin activity in various situations; II) blood adrenalin (A) and noradrenalin (NA) in different situations; III) blood ACTH and cortisol (CORT) in different situations. Continuous lines: statistically significant correlations ($P < 0.05$); broken lines; statistically probable correlations ($0.1 > P > 0.05$); +) positive, −) negative correlations.

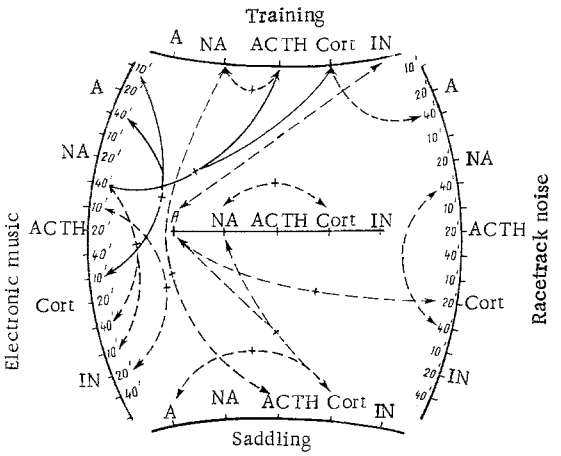

Fig. 3. Correlations between indices of SAS, PACS, and insulin activity. Legend as in Fig. 2.

40th minute of exposure and to increased excretion of adrenalin with the urine. Calculation of correlations between the indices by Spearman's method (Figs. 2 and 3) showed that the initial background level predetermines the subsequent level of activation of the system, as demonstrated by positive correlation between the background noradrenalin, ACTH, and insulin levels and their corresponding values during exposure to the stimuli. The degree of subsequent activation after exposure to moderately strong stimuli also affected the subsequent functional state of the system during more prolonged loads. This is shown by positive correlation between the ACTH level 10 and 20 min and 20 and 40 min after the beginning of exposure to the two types of sounds, and also between the insulin concentrations 10 and 20 min and 20 and 40 min after switching on the electronic music.

Positive correlations between the adrenalin and noradrenalin concentrations during training reflect simultaneous activation of both components of SAS. At rest and during weak emotional excitation (saddling) relations between the hormonal and mediator components are reciprocal in character, as shown by the negative correlation between the adrenalin and noradrenalin concentrations. Consequently, at rest and during weak excitation increased activity of one component of SAS leads to a compensatory decrease in the activity of the other component, whereas during stronger excitation the activity of the two components rises simultaneously [2].

It can be concluded from the positive correlations between the background adrenalin concentration and the adrenalin and noradrenalin concentrations during training and also between the background noradrenalin concentration and its concentration during training that background activity of one component of SAS predetermines the response of the other component to changes during training.

The positive correlation between the ACTH concentration after 20 min and cortisol concentration after 40 min of exposure to racetrack noise indicates that ACTH release precedes cortisol secretion. These data

indicate that under the conditions studied activation of the PACS takes place and negative feedback mechanisms are not brought into play [9].

The positive correlations between the catecholamine concentrations on the one hand, and the simultaneous changes in the ACTH and cortisol level on the other hand, and also data showing that changes in the catecholamine concentrations are preceded by changes in ACTH or cortisol activity shed light on the character of the connections between SAS and the PACS under the conditions of physical and emotional stimulation studied and they confirm information in the literature on the role of blood catecholamine in regulation of the PACS [8]. Correlation between the cortisol concentration after exposure for 10 min to electronic music and the adrenalin concentration after 40 min agrees with data given in the writers' survey [4] of the role of cortisol in adrenalin synthesis.

The positive correlations between the concentrations of catecholamines and insulin during training and acoustic stimulation are evidence that the insular apparatus participates in the formation of humoral-hormonal reactions. The conclusion regarding correlation between catecholamines and insulin is confirmed by data in the literature on their mutual influence [3, 10].

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