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DYNAMICS OF ERYTHROCYTE COUNT, HEMOGLOBIN, AND CATALASE ACTIVITY IN RAT BLOOD IN HYPOKINESIA, MUSCULAR ACTIVITY AND RESTORATION

G. V. Taneyeva, G. M. Potapovich, N. A. Voloshko and A. B. Uteshev

Translation of "Dinamika kolichestva eritrotsitov, gemoglobina i aktivnosti katalazy krovi krys pri gipokinezii, myshechnoy deyatel'nosti i v protsesse vosstanovleniya," Izvestiya Akademii Nauk Kazakhskoy SSR, Seriya Biologicheskaya, No. 1, 1979, pp 71-74

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16. Abstract Tests were conducted to prove that muscular exertion (in this instance swimming) of different duration and intensity, as well as hypodynamia, result in an increase of hemoglobin and number of red blood cells in peripheral blood of rats. Catalase activity increases with an increase in the duration of swimming, but only up to 6 hr; with 7-9 hr of swimming as well as in hypodynamia, catalase activity decreases, as shown in a table. It was also observed that under hypodynamia as well as in 3-, 5- and 6-hr exertion (swimming) the color index of blood decreases. Another table shows that pressure chamber treatment (for 8 min daily), alternating a 2-min negative pressure up to 35 mm Hg with 1-min positive pressure, of one week increases the erythrocyte count and hemoglobin content.

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DYNAMICS OF ERYTHROCYTE COUNT, HEMOGLOBIN, AND CATALASE ACTIVITY IN RAT BLOOD IN HYPOKINESIA, MUSCULAR ACTIVITY AND RESTORATION

G. V. Taneyeva, G. M. Potapovich, N. A. Voloshko and A. B. Uteshev
Kazakh Institute of Physical Education, Alma-Ata

Intensive muscular activity, as an adverse factor, is associated with a negative balance of phosphate macroergs and leads to disruption of the biochemical homeostasis of the organism and also provokes an adaptation reaction directed toward the preservation of homeostasis [1]. Consequently, the intense physical loads employed in current practice favor significant metabolic shifts in the peripheral blood and point to the need for studying ways of reducing these changes. For this reason a number of authors [2, 3] recommend local baroactivity to restore work capacity as well as in the treatment of articular diseases and trauma in the support-motor apparatus. /71*

In this context the present work is aimed at studying hemoglobin and erythrocyte content and changes in the catalase activity of rat blood when there is a single intensive physical load of varying duration, in hypokinesia and likewise when there is systematic training using active (baromassage) and passive (rest) restoration. Despite the important biological role played by these indices of the peripheral blood, their displacements under the experimental conditions referred to above are not sufficiently clear and, according to the data of I. I. Ivanov et al. [4], we only know of the effect of hypodynamia (15-30 days) on the activity of a number of enzymes (aminotransferase, aldolase, acid and alkaline phosphatase). N. V. Zimkin [5] has described changes in the amount of erythrocytes and hemoglobin when there is short or long term loading and also in the fatigue process.

The experiments were done with male mongrel albino rats weighing 180-250 k. The controls were intact animals with no training (10 rats). The experimental animals (8-10) were made to swim in 30-32° water under these experimental conditions:

1. A single period of uninterrupted swimming for 3, 5, 6, 7 and 9 hours. After 6 hours loading in the course of a week the rats were put in a pressure chamber specially constructed for small animals and baromassage was administered for 8 minutes

*Numbers in the margin indicate pagination in the foreign text.

with alternating 2 minutes negative pressure up to 35 mm Hg and 1 minute positive.

2. Biweekly and monthly training was begun with 15 min loading which was increased by 10 and 12 min respectively each day to an overall figure of 3 and 5 hours. Further the animals were divided into 2 subgroups: one received active restorative /72 treatment with baromassage, the other passive rest for 2, 7 and 30 days.

3. During hypokinesia the rats were kept in individual boxes for 7 days in a condition of restricted mobility.

4. The control group were also given baromassage during the week and then blood samples were taken from the caudal vein of both control and experimental animals for purposes of the study.

Hemoglobin and erythrocyte count were determined on a photoelectric erythrohemometer (model 065). Total catalase activity, established by the method of V. S. Shapot et al. [6], was expressed by the number of micromoles of hydrogen peroxide decomposed in 1 microliter of whole blood in 3 min; the catalase index was found by dividing the activity of this enzyme into the number of erythrocytes. A determination was also made of the hemoglobin/erythrocyte ratio and of the color index by multiplying this coefficient by 0.3.

Tables 1 and 2 show the results of the experiments treated statistically by the method of Ye. V. Montsevichyute-Eringene [7].

The results of the study establish the fact, that catalase activity in the peripheral blood with 3-, 5- and 6-hr exertion takes a sharp rise: 2.9, 2.3 and 2.4 times that of the control level (see Table 1). Further increase in the load during a time period up to 7 and 9 hr is characterized by a sharp decline in the activity of this enzyme to 43.0±0.4 and 44.7±3.1 respectively. With biweekly training of the animals one again notices a reliable increase in the blood's catalase activity (105.2± 0.9) as compared with control values. 7 day hypokinesia of intact animals causes a reliable decrease in catalase activity: 1.3 times that of the control level.

TABLE 1. EFFECT OF MUSCULAR ACTIVITY AND HYPOKINESIA ON SOME BLOOD INDICES

Вид воздействия a	Стат. показатель b	Активность каталазы, мкмоль/мкл c	Содержание эритроцитов, млн. в 1 мм³ d	Каталазный индекс 10^{-6} e	Содержание гемоглобина, г% f	Отношение г/эр g	Цветной показатель h
Контроль i	M±m	56,0±1,21	4,2±0,01	13,3	12,7±0,01	30,0	0,90
Нагрузка: j	M±m						
3 ч k	t	163,4±14,7 73,0	6,8±0,09 28,8	24,0	16,8±0,09 45,0	24,7	0,74
5 ч	M±m t	132,0±1,20 49,0	8,8±0,10 46,0	17,0	25,2±0,28 44,5	28,6	0,86
6 ч	M±m t	138,0±0,01 56,2	9,0±0,03 150	15,3	24,0±0,20 56,5	26,6	0,80
7 ч	M±m t	43,0±0,4 10,6	4,5±0,05 5,9	9,6	15,9±0,11 29,8	35,0	1,06
9 ч	M±m t	44,7±3,1 3,4	4,6±0,07 5,6	9,7	14,4±0,60 2,8	31,3	0,94
Тренировка: l							
1/2 мес m	M±m t	105,2±0,9 22,4	4,5±0,37 0,9	23,4	15,0±0,10 23,0	33,0	1,08
1 мес	M±m t	—	4,4±0,04 4,8	—	13,5±0,04 20	30,0	0,90
Гиподинамия n	M±m t	40,2±0,4 11,7	4,9±0,40 1,7	8,2	13,7±0,12 5,9	28,0	0,84

Key:
a. Type of effect.
b. Statistical index.
c. Catalase activity in μmol/μl.
d. Erythrocytes in millions/mm^3
e. Catalase index 10^{-6}.
f. Hb content g%.
g. Hb/er ratio.
h. Color index.
i. Control.
j. Load.
k. Hours.
l. Training.
m. Month.
n. Hypodynamia.

With 3- and 5-hr swimming the erythrocyte count rises 1.6 and 2.1 times, reaching its maximal value under a single 6-hr physical load (9.0±0.03). Longer physical ex-/73
ertion for 7 and 9 hr is marked by a slight drop in the number of erythrocytes, yet their level is reliably higher than control values.

Analogous shifts in hemoglobin content are noted with a time increase in the intensity of physical exertion. In all post-training periods there is a rise in hemoglobin concentration in the peripheral blood. Most pronounced is the value for blood pigment for hours 5 and 6 of muscular activity (25.2±0.28 and 24.0±0.20 g%). It must be noted, that in hypokinesia too one perceives a reliable increase in hemoglobin up to 13.7±0.12 g%.

TABLE 2. EFFECT OF RESTORATIVE PROCESSES ON SOME BLOOD INDICES

Вид воздействия a	Стат. показатель b	Содержание эритроцитов, млн. в 1 мм³ d	Содержание гемоглобина, г% f	Отношение г/эр g	Цветной показатель h
Контроль i	M±m	4,2±0,01	12,7±0,01	30,0	0,90
» баромассаж o	M±m	4,3±0,04	12,9±0,05	30,0	0,90
	t_1	2,4	3,8	—	—
Нагрузка 6 ч jk	M±m	9,0±0,03	24,0±0,20	26,6	0,80
» баромассаж o	M±m	4,1±0,04	12,9±0,05	31,7	0,95
	t_1	118	53,9	—	—
l Тренировка 1 мес m	M±m	4,4±0,04	13,5±0,04	30,0	0,90
» баромассаж n	M±m	4,1±0,03	12,7±0,03	30,9	0,93
o	$t_1(t)$	6,0(3,3)	16,0	—	—
» пассивный p	M±m	4,3±0,04	12,8±0,04	29,7	0,89
отдых, 2 дня q	$t_1(t)$	1,8(2,5)	12,5(2,5)	—	—

Remark: Reliability of difference t_1 calculated from relative activity.

Key: a-m. As in Table 1.
o. Baromassage.
p. Passive rest.
q. 2 days.

The catalase index with short term intensive physical exertion (3 hr swimming) and 14 day training reaches the maximal value (24×10^{-6} and 23.4×10^{-6} respectively), whereas its level in hypokinesia and also with 7- and 9-hr impact loading proves minimal (see Table 1).

As a result of the calculation of the ratio between hemoglobin content and erythrocyte count and the determination of the color index in the rats' blood when they were in a condition of restricted mobility as well as with 3-, 5- and 6-hr stroke swimming one noted a drop in the color index, proof of some anemization of the organism. With 7-hr swimming and 2 week training the color index rose a little (1.06 and 1.08) as compared with the control figure which remained at its own level during the remaining series of the experiment.

The effect of pressure activity upon the control animals is characterized by a reliable increase in the erythrocyte count and hemoglobin content (see Table 2). Active restoration, undertaken after 6-hr physical exertion, normalizes the erythrocyte count from 9.0±0.03 to 4.1±0.04 mln/mm^3, hemoglobin from 24.0±0.20 to 12.9±0.05 g%, Hb/er ratio from 26.6 to 31.7 and color index from 0.80 to 0.95. The use of baromassage and passive 2 day rest after monthly training of the rats testifies to a more rapid normalization of the blood indices using the first rather than the second type

with a difference reliability (t) respectively equal to 3.3 and 2.5. /74

The significant increase in catalase activity, 2.9-2.4 times, and the rise in the catalase index with 3-, 5- and 6-hr swimming (see Table 1) may be explained by the emigration of the enzyme into the blood due to a change in the permeability of cell membranes and disruption of the process of oxidative phosphorylation in a number of organs and tissues [8].

Further increase of physical exertion time to 7 and 9 hours, expressed in diminished catalase activity and a lower catalase index seems to be associated with accumulation of peroxide compounds in the organism. This fact was pointed out by R. N. Feinstein et al. [9] in due course, after they noticed a drop in the catalase activity of the blood of rats given hydrogen peroxide. An increase in erythrocytes and hemoglobin in the blood without a change in the color index favors increased oxygen volume and this, according to research data [5, 10], is associated with the execution of short term intensive physical work.

Prolonged adaptation of the trained organism, which is characterized by a rise in the amount and intensity of enzyme synthesis and affects their activity [1, 10] is reinforced, according to our findings, by the increase in catalase activity in half-month training (1.9 times, Table 1) and as the amount of hemoglobin and erythrocytes increases it points to stimulation of the defense forces of the organism.

On the basis of what has been set forth the following conclusions were reached:

-- muscular activity (swimming) of varying length and intensity as well as hypodynamia are characterized by an increase in hemoglobin content and erythrocyte count in the peripheral blood of the rat;

-- the catalase activity of the blood, when swimming is extended to 6 hours, increases; half-month training likewise is accompanied by increased activity by this chromoprotein; with 7- and 9-hour exertion and hypodynamia catalase activity drops.

--pressure normalizes the shifts noted in hemoglobin content and erythrocyte count.

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