INVESTIGATING THE QUANTITATIVE CHANGES AND FUNCTIONAL EQUIVALENCE OF ERYTHROCYTES IN EXPERIMENTAL HYPER- AND HYPOKINESIA

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Literature data concerning adaptational changes manifested by the number of erythrocytes in the peripheral blood, and by their hemoglobin content in hyper- and hypokinesia are contradictory — (1, 3, 4, 8, 9, 14). There are publications pointing to cyclic changes when this particular indicator is assayed (12) — initially they increase during hypokinesia, and decrease at later terms. A similar dynamics in terms of the count of red blood cells was described by the author of the paper (7) subsequent to systematic motor loading of experimental animals. In the literature there are no data available concerning the state of biochemical systems providing for the integrity and functional fitness of erythrocytes during hyper- and hypokinesia.

To further clarify changes in erythrocytes in conditions of intensive or restricted motor regime, a study of their functional equivalence by means of catalase activity measurements, and through staining index determination was also carried out.

Material and method

The experiment was conducted on a series of 64 white male rats of the Wistar line, with 126 grams mean body weight at the beginning of the experiment. The animals were divided up in three groups. Group one (control) consisted of twenty animals, kept under ordinary vivarium conditions, and distributed in two cages of 10 animals each. Group two (20 animals) were compelled to swim in a water basin at temperature 33—35° C. In the beginning, the swimming lasted for 15 minutes with weights fixed to the tail (5 per cent of body weight). The duration of physical exertion was increased by 15 min at weekly intervals, but never exceeded one hour. Physical activity in the third group, totalling 21 animals, was restricted through confinement in small individual cages.

The animals were sacrificed at three fixed terms: 16, 36 and 80 days from the beginning of the experiment. Assessment was made of body weight, hematocrit value, erythrocyte number in the peripheral blood, hemoglobin content after the cyanhemoglobin method, and catalase activity according to A. N. Bah and S. R. Zubkova (1950). From the obtained data the values of catalase number and staining index were computed. The data were treated after the variation statistics method, with differences at P below 0.05 being accepted as reliable.

Results and discussion

The results of the experiment are illustrated in Table 1. The erythrocytes of animals subjected to systematic loading through muscular work decrease during the three observation intervals accordingly by 7.5, 9.3 and 2.9 per cent relative to control values (Fig. 1,I), with differences of the values for the first two intervals being statistically reliable. During the same periods, the erythrocytes of immobilized animals increase accordingly by 0.01, 0.8 and 10.6 per cent (Fig. 1, II), with the difference for the 80-day immobilization period only being statistically reliable.

Table 1

Indicators	Animal group	16 days			36 days			80 days		
		$\bar{x}$	S	Sx	$\bar{x}$	S	Sx	$\bar{x}$	S	Sx
Hematocrit	C	50.50	2.97	1.12	48.13	2.85	1.08	46.00	2.65	1.08
	S	46.86	1.47	0.60	47.29	2.85	1.16	50.83	2.64	1.18
	HK	52.86	2.67	1.09	50.43	3.02	1.23	54.71	2.19	0.89
Erythrocytes (in mil.)	C	8.423	0.54	0.20	8.074	0.57	0.22	8.107	0.55	0.22
	S	7.788	0.40	1.16	7.324	0.68	0.28	7.875	0.85	0.38
	HK	8.423	0.54	0.22	8.137	1.24	0.51	8.966	0.70	0,29
Hemoglobin (in g %)	C	16.93	0.85	0.32	16.51	0.59	0.22	14.70	1.00	0.41
	S	15.67	0.46	0.19	14.14	0.97	0.40	16.22	1.09	0.49
	HK	16.86	0.93	0.38	15.39	0.97	0.40	15.95	1.20	0.49
Staining index	C	0.63	0.02	0.01	0.64	0.06	0.02	0.57	0.02	0.01
	S	0.63	0.04	0.02	0.61	0.06	0.02	0.65	0.08	0.04
	HK	0.63	0.04	0.02	0.60	0.08	0.03	0.56	0.23	0.09
Catalase activity	C	9.88	0.96	0.36	8.22	0.84	0.32	7.75	1.44	0.59
	S	10.19	1.07	0.44	7.73	1.69	0.69	8.16	0.69	0.31
	HK	6.97	1.29	0.53	6.98	1.07	0.44	7.40	0.36	0.15
Catalase number	C	1.18	0.14	0.05	1.02	0.07	0.03	0.90	0.10	0.04
	S	1.32	0.22	0.09	1.06	0.28	0.11	1.04	0.20	0.09
	HK	0.82	0.14	0.06	0.88	0.28	0.11	0.83	0.10	0.04

Note: C — Control group
S — Physical exertion: swimming
HK — immobilized

The changes in erythrocytes manifested with catalase activity, and assayed by the catalase number, are diametrically opposed — increased in hyperkinesia resp. by 11.9, 3.9 and 15.6 per cent (Fig. 1, I), and decreased in hypokinesia resp. by 30.5, 13.7 and 7.8 per cent (Fig. 1, II). Only the difference for the 16th day of immobilization is statistically reliable.

If the indicators observed among immobilized animals are compared with those in animals subjected to systematic loading through physical exer-

tion, the regularities referred to above become more clearcut — increase in the number of erythrocytes of the immobilized animals resp. by 8.2, 11.1 and 13.9 per cent, and reduction of their catalase number for the three terms respectively by 37.9, 17 and 20.2 per cent (Fig. 1, III), at statistically reliable differences.

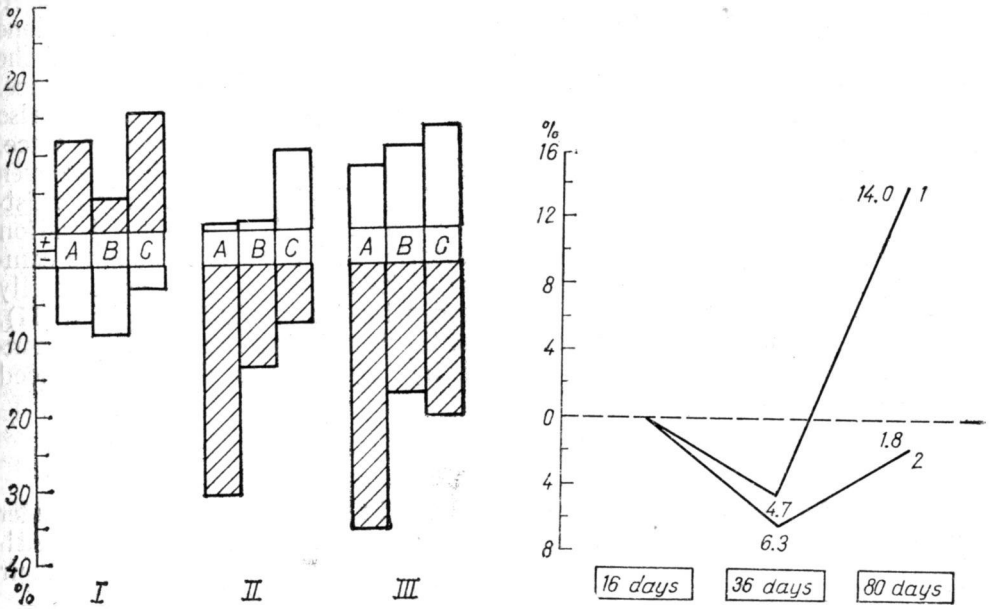

Fig. 1: Percentual change in the number of erythrocytes (white columns) and catalase number (hatched columns) in swimming (I) and immobilized (II) male white rats relative to controls, and of immobilized relative to animals subjected to physical exertion (III) during experiment lasting 16 (A), 36 (B) and 80 (C) days.

Fig. 2: Percentual change in staining index values of erythrocytes in male white rats subjected to motor loading (l) and immobilization (2) at the varicus experimental terms.

Changes manifested with the staining index are shown in Fig. 2. At 16 days from the beginning of the experiment, this particular indicator for either group of experimental animals proves to be unchanged relative to the control. Within 36 days it falls in both groups — by 4.7 per cent among the animals with hyperkinesia, and by 6.3 per cent among the immobilized ones. At the end of the experiment, a dissociation between the values of the staining index occurs. While in the group of animals exposed to systematic physical exertion it is by 14 per cent higher relative to the control, which difference is statistically reliable, in the immobilized animals this particular indicator is 1.8 per cent lower than the values for the controls.

Having in mind that catalase is one of the biochemical systems responsible for maintaining the integrity of erythrocytes, and more particularly, that it protects the hemoglobin from destruction under the effect of hydrogen peroxide (13), it becomes clear why certain authors assay the functional implication of red blood cells by means of investigating the activity of cata-

lase and glucose-6-phosphate dehydrogenase, and accordingly draw conclusions about the changes in this significance during various effects on the organism (10). We agree with the latter because, according to data of a personal research (6), the catalase activity of erythrocytes is stimulated by i. v. injection of hydrogen peroxide. Against the background of the above mentioned facts the assumption is warranted that interpretation of the changes in peripheral blood by the erythrocytes in hyper- and hypokinesia should be done not merely on the basis of their number, but also through assessment of the biochemical systems securing their integrity and functional equivalence. In our opinion, the latter notion should be broadened in order to include also data concerning the hemoglobin content of the individual erythrocyte since, as evident from the data submitted, the staining index shows an increase even though in the later terms of hyperkinesia. Thus, the inverse correlation existing between the number of erythrocytes and their hemoglobin saturation is once again demonstrated. This is an essential fact because to achieve complete hemoglobin saturation in the course of its reduction, such as normally observed during hypokinesia, a higher oxygen tension would be required (11). Our results elucidate up to a great extent the conflicting literature data concerning the quantitative changes assayed by erythrocytes during enhanced or restricted motor regime.

Conclusions

1. The assessment of changes in erythrocytes in the peripheral blood under conditions of hyper- and hypokinesia could hardly be made through investigating their number alone, since biochemical systems substantiating their integrity and functional significance should be also assayed.
2. Erythrocyte concentration in the peripheral blood of white male rats subjected to systematic physical exertion decreases, whilst in immobilized animals it increases. The catalase activity of a single erythrocyte undergoes changes diametrically opposed to those described.
3. The hemoglobin content of individual erythrocytes in hyperkinesia is above the values for animals kept under conditions of hypokinesia, and in case of long-term treatment (80 days), it exceeds the values of control animals also.
4. The changes in the single erythrocyte during hyperkinesia, manifested with catalase activity and hemoglobin content, point to an enhancement of its functional possibilities, namely increased endurance to hemolysis agents, and improved oxygen saturation capacity. The changes in the listed indicators during hypokinesia are diametrically opposed.

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ИЗУЧЕНИЕ КОЛИЧЕСТВЕННЫХ ИЗМЕНЕНИЙ И ФУНКЦИОНАЛЬНОЙ РАВНОЗНАЧНОСТИ ЭРИТРОЦИТОВ ПРИ ЭКСПЕРИМЕНТАЛЬНОЙ ГИПЕР- И ГИПОКИНЕЗИИ

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РЕЗЮМЕ

Проведено исследование числа эритроцитов, их гемоглобинового содержания и каталазной активности в трех группах белых мужских крыс: контрольных, обездвиженных и подвергнутых систематической двигательной нагрузке. Обнаружено уменьшение числа эритроцитов с увеличением их каталазной активности у животных с двигательной нагрузкой. У них же, в поздние сроки опыта, увеличен и цветовой показатель. Изменения при гипокинезии диаметрально противоположные. Полученные данные толкуются как выражение функциональной значимости эритроцитов, независимо от их количественного снижения под влиянием систематического двигательного режима и уменьшения ее при долгосрочной гипокинезии.