Effects of Substance S-1 on Energy Metabolism and cAMP Concentration in Rat Tissues during Physical Stress

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Substance S-1 increased energetic potential of skeletal muscles and increased cAMP level in the brain, heart, and liver of male Wistar rats at rest and after forced swimming.

Key Words: *serum; energy potential; cAMP; ATP; AMP*

Substance S-1 obtained from chicken blood serum contains a considerable amount of peptides with a molecular weight <10 kDa. This preparation improves hearing in deaf rats [3].

Here we studied the effects of substance S-1 on the contents of ADP, AMP, and ATP in skeletal muscles and concentration of cAMP in the brain, liver, and heart during physical stress.

MATERIALS AND METHODS

Substance S-1 is lyophilized chicken plasma obtained during electrical shock (II-III degree) [2] and containing peptide regulators with a molecular weight <14 kDa.

Experiments were performed on 40 male Wistar rats weighing 280-300 g. The animals were divided into 4 groups (10 rats per group).

The rats of groups 1 (control) and 3 intraperitoneally received 1 ml physiological saline. Substance S-1 in a dose of 10 mg per 100 g body weight (1 ml) was administered to group 2 and 4 animals. Nonanesthetized rats of groups 1 and 2 were decapitated 30 min postinjection.

The animals of groups 3 and 4 were placed in a reservoir with water (25°C) with a weight on the tail (30% body weight). The rats with signs of agony were removed from water and decapitated.

We studied the brain, heart, and liver (organs that function at energy overload during extreme adaptation) and skeletal muscles. Tissue samples from each rat were weighted, cooled with isotonic NaCl, and rapidly frozen in liquid nitrogen. Sampling was performed not later than 5-6 min after the start of physical exercise.

The contents of ATP, ADP, and AMP were measured in rat skeletal muscles. Nucleotides were separated by the method of anion-exchange column chromatography. The concentrations of ATP, ADP, and AMP were measured on a Hitachi-557 spectrophotometer at 256 nm (UV range).

The energy potential was calculated as follows [5]: (ATP+0.5ADP)/(ATP+ADP+AMP).

The concentration of cAMP in the brain, heart, and liver was measured by radioimmunoassay with special kits (Amersham).

The amount of labeled cAMP was determined on a ZhS-8 counter. The results were analyzed by nonparametric methods.

RESULTS

Significant intergroup differences were revealed in the contents of ATP, ADP, and AMP and increase in the energy potential: groups 3-4 and groups 1-2 ($p<0.05$); and group 3 and group 4 ($p<0.05$, Table 1).

The adenyl system was studied under normal conditions and 30 min after mild stress produced by injection and isolation (control group). Substance S-1 shifted the contents of ATP and ADP in muscle tissue to the upper limits of normal. AMP concentration decreased to the lower limits of normal. It can be hypothesized that substance S-1 promotes the increase in

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TABLE 1. Contents of ATP, ADP, and AMP and Energy Potential in Rats Skeletal Muscles after Administration of Substance S-1 (*M*±*m*)

Group	Nucleotide content, μmol/g tissue			Energy potential (arbitrary index)
	ATP	ADP	AMP	
1 (control)	7.55±0.19	0.95±0.12	0.25±0.08	0.917±0.280
2	7.89±0.12	1.12±0.11	0.14±0.05	0.923±0.125
3	1.34±0.08*	3.56±0.17*	0.78±0.07*	0.549±0.140*
4	4.78±0.17^{+}	2.55±0.11^{+}	0.33±0.09^{+}	0.790±0.095^{+}

Note. Here and in Table 2: $p<0.05$: *compared to the control; $^{+}$compared to group 3 rats.

the energy reserve in muscle tissue. This hypothesis was confirmed after evaluation of the energy potential.

In group 3 rats subjected to forced swimming the content of ATP decreased, while the concentrations of ADP and AMP increased compared to the control.

Changes in group 4 rats after extreme exercise were similar to those in group 3 animals. However, ATP content in these rats remained high. The energy potential in group 4 rats was 43% higher than in group 3 animals ($p<0.05$).

We compared cAMP content in the heart, liver, and brain in group 1 and 2 rats. Substance S-1 increased cAMP level in the brain by 15.9% ($p<0.01$). However, this compound produced no changes in the heart and liver (Table 2).

Extreme exercise was followed by a decrease in cAMP concentration in the brain, heart, and liver of group 3 and 4 rats. It should be emphasized that substance S-1 produced a less pronounced decrease in cAMP content. In group 4 rats cAMP level in the brain and heart was higher than in group 3 animals by 92 and 69% ($p<0.05$).

The mechanisms of changes in energy metabolism in cells, tissues, and organism produced by substance S-1 require further investigations.

TABLE 2. cAMP Content in the Brain, Heart, and Liver after Administration of Substance S-1 (*M*±*m*)

Group	cAMP content, pmol/g wet tissue		
	brain	heart	liver
1 (control)	3.95±0.58	3.07±0.11	2.75±0.18
2	4.58±0.23	3.26±0.16	2.98±0.99
3	0.82±0.13*	0.49±0.17*	1.01±0.07*
4	1.58±0.13^{+}	0.83±0.14^{+}	1.27±0.08

Our results indicate that substance S-1 increases the energy potential in skeletal muscles and promotes the rise in cAMP level in the brain and heart of rats after extreme physical exercise.

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