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Content of bioelements in the lungs and liver in rats with alimentary obesity

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ABSTRACT

The synchrotron radiation X-ray fluorescence technique (SRXRF) was applied to the determination of K, Ca, Mn, Fe, Cu, Zn, Se, Br, Rb, and Sr concentrations in the liver and lungs in Wistar rats. The animals in the experiment included (1) healthy rats, (2) rats with alimentary obesity (AO), and (3) rats with alimentary obesity that were being given zinc sulphate with water for a long time (AO + Zn). Each group was divided into two subgroups. The experiment with the first subgroup was terminated with the animals in the state of physiological hunger and subsequent retrieval of liver and lung tissue, while the animals of the second subgroup were sacrificed two hours after ingestion of lard. The rats in physiological hunger manifested intergroup differences in the content of the bioelements (BEs) neither in the liver nor in the lungs. The rats with AO, as compared with the healthy animals, demonstrated in physiological hunger redistribution of inter-element correlations (IECs), which is an indirect reflection of sustained metabolic disorder. Additional zinc in the rats' ration did not affect their body weight and the concentration of the BEs (including zinc) in the liver and the lungs. However, the IECs in the tissues of these animals in physiological hunger also changed. This redistribution differed from that in the rats with AO. The IECs soon after ingestion of lard also changed, which also reflects sustained changes in the metabolism in the animals.

1. Introduction

Obesity is one of the major health and social problems in the world today that affects over 30% of population in economically developed countries [1] and is spreading fast in developing countries. According to figures from the International Association for the Study of Obesity, the annual growth rate of obesity among children increased ten times in the period from 1970 to 2000 [2].

The efficiency of obesity treatment being still low, we cannot exclude other factors that may affect its origin and development, including deficiency or excess of some bioactive elements in the body tissues. The correlation of micronutrients and obesity has been repeatedly investigated. In paper [3] it was reported that the absorption and retention of iron in obese mice was approximately 2 times as high as in control animals. A positive correlation was found between the fat content in body and the Fe concentration in the serum of the Indians [4]. The hair of obese women contained elevated concentrations of K, Hg, Pb and reduced Ca, Mg, Zn and I levels [5] . The Zn and Cu concentrations in obese rats were lower in the liver and higher in the muscles and femurs as compared with the control group of healthy animals [6]. Zinc is one of metabolically active BEs. It is present in almost 300 enzyme structures [7,8]. Numerous researchers have found relationship between intake of zinc and obesity origin. However, some researchers believe obesity to be forwarded by excessive zinc in body [9–12], while others think that obesity is promoted by shortage of zinc [13,14].

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Table 1
Concentrations (μg/g) of analyzed elements in liver and lungs. (Mean values ± confidence intervals, $p = 0.05$).

Physiological hunger						
Element	Liver			Lungs		
	Control	AO	AO + Zn	Control	AO	AO + Zn
K	10000 ± 1600	10000 ± 1700	9000 ± 2200	9000 ± 1700	8900 ± 820	8900 ± 1400
Ca	110 ± 29	100 ± 29	100 ± 21	260 ± 80	270 ± 30	270 ± 46
Mn	8 ± 2.1	6 ± 2.0	5 ± 1.7	1.1 ± 0.3	1.1 ± 0.4	0.9 ± 0.20
Fe	1200 ± 450	1100 ± 430	800 ± 380	500 ± 180	500 ± 110	400 ± 110
Cu	13 ± 4.0	12 ± 3.0	10 ± 3.0	4 ± 1.3	3.8 ± 0.9	4 ± 1.3
Zn	120 ± 33	120 ± 29	100 ± 30	60 ± 16	60 ± 10	60 ± 14
Se	5 ± 1.4	3.7 ± 0.90	3.1 ± 0.90	1.3 ± 0.30	1.3 ± 0.21	1.4 ± 0.40
Br	40 ± 14	38 ± 9.0	40 ± 10	90 ± 29	90 ± 12	90 ± 22
Rb	60 ± 20	60 ± 20	50 ± 16	24 ± 8.0	22 ± 4.0	26 ± 7.0
Sr	0.10 ± 0.040	0.2 ± 0.10	0.12 ± 0.030	0.26 ± 0.080	0.4 ± 0.13	0.31 ± 0.070

After intake of lard						
Element	Liver			Lung		
	Control	AO	AO + Zn	Control	AO	AO + Zn
K	11000 ± 2000	9000 ± 1400	9000 ± 1500	7000 ± 1800	9000 ± 1200	8000 ± 1200
Ca	130 ± 19	110 ± 35	100 ± 19	260 ± 67	320 ± 84	320 ± 74
Mn	7 ± 1.3	5 ± 1.0	6 ± 1.4	1.1 ± 0.40	1.3 ± 0.40	1.6 ± 0.40
Fe	1000 ± 300	800 ± 200	800 ± 250	380 ± 78	510 ± 84	470 ± 96
Cu	11 ± 2.0	9 ± 2.0	10 ± 4.0	2.9 ± 0.80	5.1 ± 0.80	4 ± 1.0
Zn	90 ± 18	80 ± 12	90 ± 22	50 ± 11	70 ± 10	60 ± 9
Se	3.7 ± 0.90	2.6 ± 0.50	2.7 ± 0.80	1.1 ± 0.20	1.5 ± 0.30	1.3 ± 0.30
Br	37 ± 6.0	32 ± 9.1	31 ± 4.0	70 ± 19	90 ± 17	90 ± 16
Rb	41 ± 8.0	32 ± 6.0	40 ± 10	16 ± 3.0	23 ± 5.0	21 ± 5.0
Sr	0.12 ± 0.030	0.17 ± 0.090	0.09 ± 0.042	0.3 ± 0.12	0.62 ± 0.37	0.35 ± 0.15

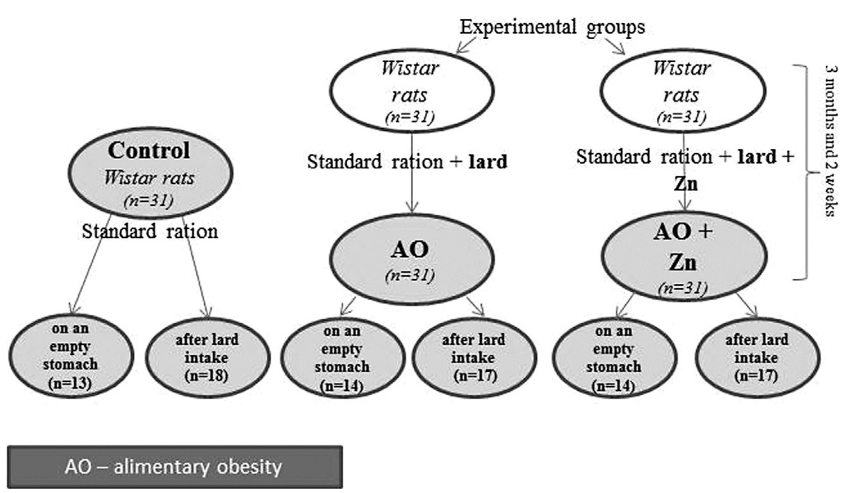

Fig. 1. Scheme of the experiment.

In obesity, a pathological system arises with formation of stable metabolic disorder. The liver is the central organ of chemical homeostasis, which is involved in the metabolism of proteins, fats and carbohydrates. The lungs are known to perform a lot of non-respiratory functions and together with the liver they are involved in the fat metabolism [15–19]. Given the intense involvement of the BEs in metabolic processes it would be reasonable to research not only their total content but also inter-element correlations at the early stage of obesity formation. It will allow to diagnose the formation of pathology systems and to enable more efficient treatment.

The IECs in liver were found in the following reports: [20–22]. There was no information about IECs in metabolic active organs of animals or humans with AO found in the literature. The purpose of this study was to find out how the concentrations of the chemical elements and inter-element correlations in the liver and lungs in rats reflect metabolic changes under the influence of food ration.

2. Materials and methods

2.1. Experimental design

The experiment was performed on gnotobiotic outbred Wistar rats with an initial body weight of 200–300 g and in accordance with the rules of humane treatment of animals (the Declaration of Helsinki of the World Medical Association). The animals were delivered from the nursery of the Institute of Cytology and Genetics SB RAS.

The animals in the control group received the vivarium ration, i.e., special pelleted feed for animals with no pathogenic microflora (made by the automatic plant of the company Assortiment-Agro, Sergiev Posad, Russia). In the two experimental groups, this vivarium ration was supplemented with lard, which was available to the animals throughout the experiment (Fig. 1). The lard was bought once for the entire experiment (from one manufacturer). The rats in