Acta Physica Academiae Scientiarum Hungaricae, 53 (1—2), pp. 159—164 (1982)

INVESTIGATION OF CHANGE OF MINERAL METABOLISM OF COSMONAUTS BY X-RAY FLUORESCENCE METHOD*

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Micro-element determination was carried out in the blood serum and in the hair samples of the first Soviet—Hungarian space team, by using the techniques of X-ray fluorescence analysis. The concentration of Cl, K, Ca, Br, Cu and Zn was determined before and after the space flight.

Introduction

Blood circulation transports nutritive materials to the tissues and organs of the human body. This transport for nutritive materials and for the end products of metabolism has evolved under terrestrial conditions (in the presence of the force of gravity). Thus, its undisturbed operation is guaranteed under earthly conditions.

Under the conditions of weightlessness the circulation resistance of the circulatory system of cosmonauts changes because of the absence of gravity, and this results in a change in the blood circulation. There is a stagnation in the lower extremities, at the same time an enchanced circulation in head and trunk. This affects the household of water and mineral materials of the organism, i.e. the metabolism of the human organism [1—3]. Investigations into the modification of metabolism as well as its knowledge in order to prevent and to avoid its harmful effects are very important from the point of view of space research.

Really effective studies on the metabolic processes would need the continuous registration of the changes but so far there is no suitable instrument; however, the human organism offers some possibility.

Human hair is a special end product of metabolism. The constituents of hair are determined during its development by metabolism. However, after the development (a

* Dedicated to Prof. I. Tarján on his 70th birthday.

few days) [4], the internal composition does not change. The speed of the growth of human hair is 0.3—0.5 mm/day. In this way the human hair stores the changes of metabolism taking place in the immediate environment of the hair follicle in chronological order. The measurement of macro- and micro-element concentration in hair, supposing that it was not affected by some external contamination, is suitable for investigating certain changes in human metabolism. The advantage of this method is that sample collection is painless, the samples do not decompose, thus storage does not require special precautions. The results obtained in this way can be compared with a similar analysis of blood serum.

The micro-element determination carried out on the blood serum and on hair samples of the two cosmonauts of the first Soviet—Hungarian space team are given in the present paper.

Sample preparation, measurement

Four blood serum samples were taken from both cosmonauts. Samples were taken on 21 April, 14 May, 4 June and 9 June 1980. The space mission lasted from 26 May to 3 June. The samples (approx. 0.5 ml each) were received in plastic test tubes sealed with paraffin. They were stored in a refrigerator (at $-20\,^{\circ}C$) before they were delivered to us. Other special treatment is not known. The samples were dried (0.1 ml) into spots of about 1 cm diameter. Two parallel preparations were made of every sample thereby enabling parallel measurements.

Measurements of the hair and beard samples were carried out in the natural, original form of the samples, i.e. without washing them before measurement.

The samples were analysed by X-ray fluorescence method. The schematic arrangement of the measuring set-up can be seen in Fig. 1. The energy resolution (FWHM) of the instrument is 190 eV. The Cl, K and Ca concentration of the samples

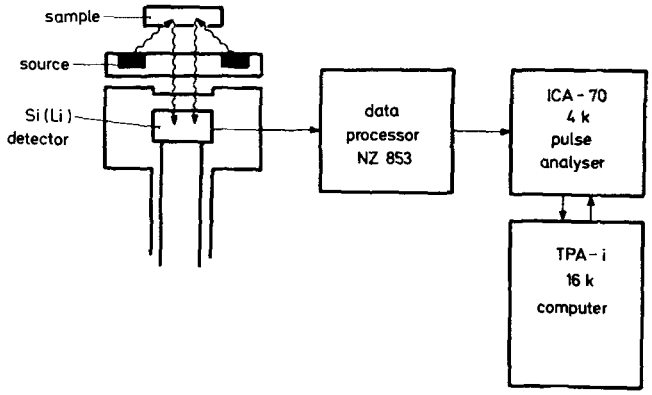

Fig. 1. Set-up of the instrumentation used for the measurements

was measured with Fe-55 (750 MBq) source the Cu, Zn and Br concentration was measured with I-125 (370 MBq) exciting source. The evaluation of X-ray spectra was made by a TPAi computer.

Results

The I-125 source induced X-ray spectra of the serum samples of the two cosmonauts before and after the flight can be seen in Fig. 2. The dates (duration) of the flight are also given in the Figure. The Cu, Zn and Br values were determined from the measurement with I-125 (the Fe line in the spectrum comes from the instrument).

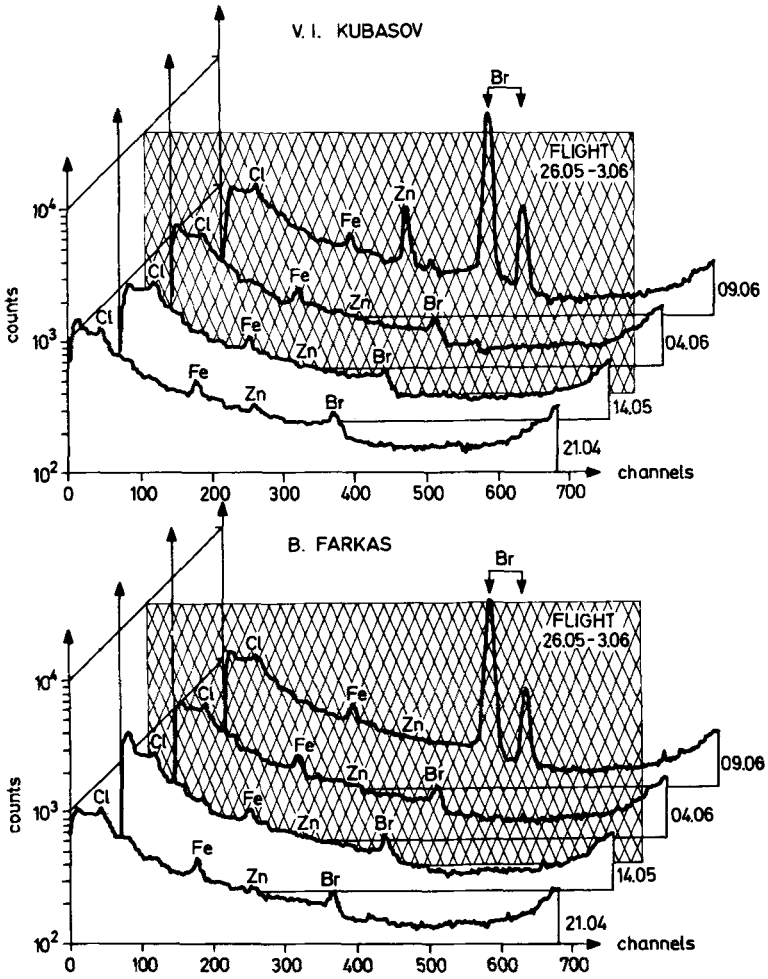

Fig. 2. Spectra of blood serum samples

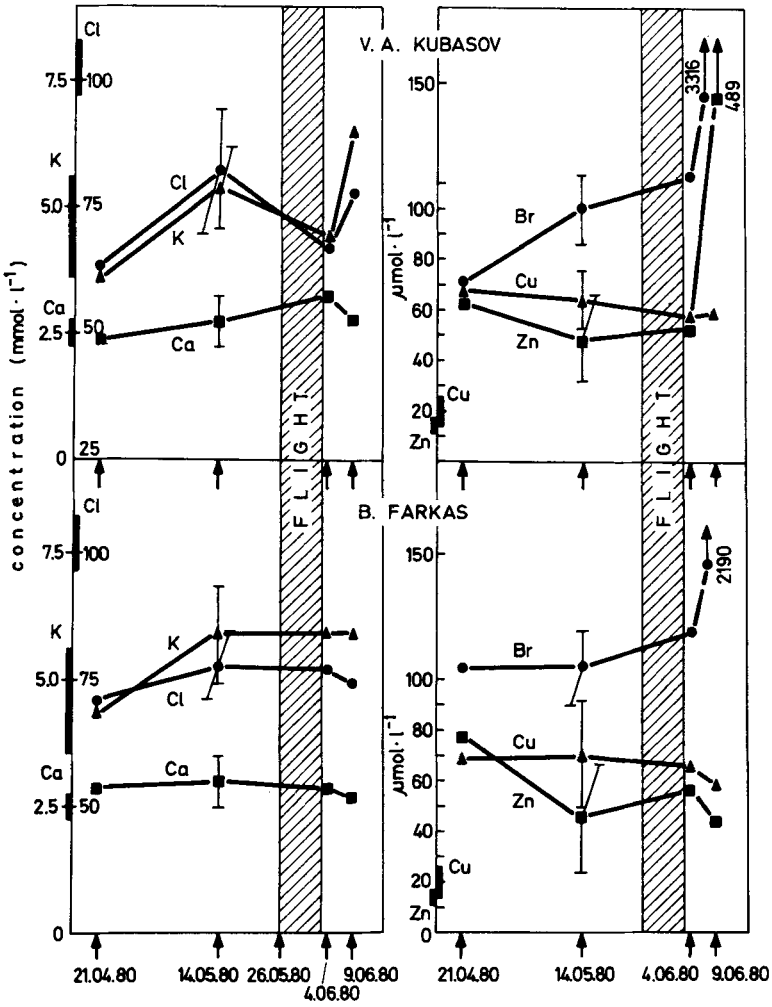

Fig. 3. Summary of results for blood serum samples

The concentrations of mineral elements measured in the serum samples of the two cosmonauts are given as a function of time (see Fig. 3). The dates (duration) are also indicated in this Figure; the normal values of certain elements are shown on the vertical axis [5].

Discussion

The K and Ca values found in the serum before and after space flight correspond to the normal values and remain unchanged even if taking into account the error limits (Fig. 3). However, the measured Cl content does not reach the normal value, it is about

65—80% of the normal value and its level did not change before and after the space flight.

The measured Zn and Cu levels are many times higher than the normal value [5] in the serum of both cosmonauts. This is presumably due to the fact that the detection limit with 0.1 ml serum is just above the upper limit of the normal value and small Zn and Cu contaminations are present in parts of the measuring equipment. (In Fig. 2 the Zn line can be seen only in"Kubasov's last spectrum".) The Zn and Cu values under the detection limit cannot be evaluated. The Zn value for Cosmonaut Kubasov is 28.3 ± 1.3 times the normal upper limit in the sample taken on the fifth day after landing; this value is unchanged for Cosmonaut Farkas.

Br levels, with the exception of the sample taken on the fifth day after landing, can be compared with the serum level of other healthy individuals. In the last sample (see Figs 2 and 3) the Br level increases to a value which is $\simeq 30$ times higher than the former values for both cosmonauts.

In Fig. 4 the X-ray spectrum of Farkas's beard sample taken before the space flight can be seen. It is obvious from the Figure that the Zn concentration can be measured with considerably higher sensitivity while Br can be measured with the same sensitivity if we use hair samples for analyses instead of blood serum samples.

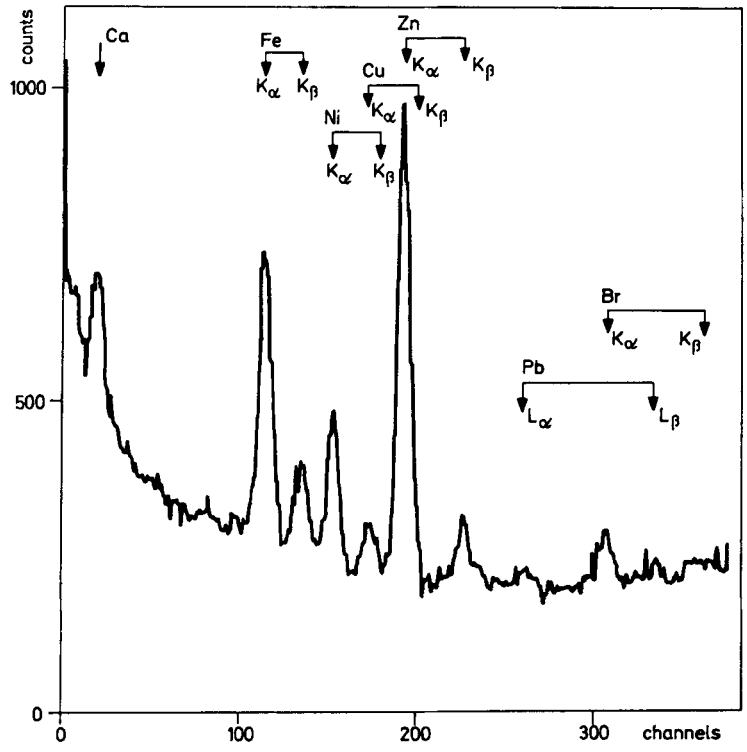

Fig. 4. Spectrum of beard samples of B. Farkas before his space flight (22—26 May 1980)

Had the beard samples been collected separately day by day before, during and after the space flight, it would have been possible to analyse the changes in Zn and Br content for every day and probably to clear up the origin of or reason for the changes. On the basis of the above, we suggest that the investigation of changes of mineral element metabolism in cosmonauts by analysing beard samples is worthy of greater consideration.

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