CHANGES OF THE CONCENTRATION OF SODIUM AND POTASSIUM IONS IN HUMAN URINE AND SALIVA DURING "ELEVATIONS" IN A BAROCHAMBER TO THE ALTITUDE OF 5000 AND 6000 m

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A number of investigations [1-7] were devoted to the problem of the effect of hypoxia on sodium and potassium metabolism in man and in animals. However, results of different studies somewhat contradict each other. Considering the importance of a thorough study of mechanisms of regulation and compensation of functions under hypoxia, we made it our purpose to study the sodium-potassium balance in human beings at different degrees of hypoxia encountered in aviation medicine.

Because of the difficulties of obtaining repeated blood samples from persons during "elevations" in a barochamber, we investigated potassium and sodium concentrations in samples of urine and saliva.

METHOD

We investigated individuals under conditions of "elevation" in a stationary barochamber, type SBK-48, to altitudes of 5000 and 6000 m. The exposure in 5000 m "elevations" was 30 min , and that in 6000 m, 15 min.

Potassium and sodium concentrations were determined in most cases in the urine, and in a few cases in saliva. Five samples of urine at 40-50 min intervals were taken. The first sample was taken before the "elevation" in the barochamber, and the four subsequent ones, after the "elevation". Saliva was obtained by means of Löschli capsules, also in 5 samples: before the "elevation," during the first 15 minutes of "elevation," during the next 15 minutes of "elevation" and after "descent to earth" (2 samples with a 10 minute interval).

A 2% solution of citric acid was used as stimulant. Potassium and sodium concentrations in saliva and urine were determined by means of flame photometry (Zeiss flame photometer, model 3).

RESULTS

26 persons were investigated in 5000 m "elevations". They all reacted well under these conditions.

Table 1 shows the nature of onsetting changes in sodium and potassium concentrations in the urine of this group of persons.

As seen in Table 1, considerable changes in the ratio of the elements under investigations took place after a 30 minute "elevation" to 5000 m. Sodium concentration had a tendency to decrease, while that of potassium, to increase; in the first post-"elevation" sample these changes were not seen, but in the second one they were seen clearly. Changes in the Na/K ratio were most obvious. Thus, before "elevation" this ratio was equal to 2.8, in the second sample it was 2.8, in the third, 2.3, in the fourth 2.2 and in the fifth 2.3.

Changes in sodium and potassium concentrations in the saliva were similar in all cases. Tables 2 and 3 show representative results obtained for 2 persons.

During the first 15 minutes of "elevation" there was pronounced increase in potassium and sodium concentrations. During the next 15 minutes concentrations of sodium and potassium became lower, but the concentration of potassium remained higher than the original concentration. The next two samples showed that during the first 20 minutes after "elevation" the concentration of potassium showed a tendency to return to the original level, but the concentration of sodium during this period remained lowered.

Twenty-four persons were investigated in 6000 m "elevations"; 18 of these reacted well, while 6 showed a lowered resistance to hypoxia. Clinically, lowered resistance was expressed in paling and hyperhydrosis, in lowering

of arterial pressure and slowing of pulse, and in one case this was accompanied by a temporary loss of consciousness.

It must be said that all persons investigated in the 6000 m "elevation" experiments, had been "elevated" to 5000 m 2 to 4 days previously.

Table 4 shows the changes which took place in sodium and potassium concentrations in persons who reacted well to 6000 m "elevation".

TABLE 1. Changes in Potassium and Sodium Concentrations in Urine after a 30 Minute "Elevation" to 5000 m

Sample	Concentration of sodium (mg%)	Concentration of potassium (mg%)	Ratio Na/K
First (before "elevation")	487.7	183.9	2.8
Second	482.6	177.1	2.8
Third	473.9	222.0	2.3
Fourth	432.0	240.5	2.2
	t=2.87[1]	t=3.23	t=3.00
Fifth	461.4	232.9	2.3

[1] Significance of the arithmetic mean of the fourth sample (Table 1) and the third sample (Table 5) is given in relation to the first (original) sample.

TABLE 2. Ionic Changes in the Saliva of K., 31 years of age

Sample	Sodium Concentration (mg%)	Potassium Concentration (mg%)	Ratio Na/K
First	27.9	143.0	0.19
Second	31.9	173.0	0.18
Third	12.1	151.0	0.08
Fourth	20.1	160.0	0.12
Fifth	12.1	120.0	0.10

TABLE 3. Ionic Changes in the Saliva of Z., 39 years of age

Sample	Sodium Concentration (mg%)	Potassium Concentration (mg%)	Ratio Na/K
First	15.9	81.0	0.19
Second	25.4	101.5	0.25
Third	15.9	93.0	0.16
Fourth	9.4	83.0	0.11
Fifth	6.3	70.0	0.09

As seen in Table 4, this "elevation" did not produce significant changes in the ratios of the elements investigated. Thus, the Na/K ratio in the first urine sample was on the average 2.7, and after "elevation" in the baro-chamber it was 2.5, 2.6, 2.7, 2.6, respectively, i.e. it remained close to the original ratio.

Information on the changes which took place in persons with lowered resistance to the 6000 m "elevation" is given in Table 5. Here, a definite change is seen: sodium concentration was decreased and potassium concentration was increased. Thus, the Na/K ratio decreased from 3.2 in the first sample to 1.7 in the third.

As was seen from the analysis of saliva, the change was most pronounced during the first minutes of hypoxia; during the first few minutes after return to normal conditions, there was a tendency to return to the original value. These changes were mainly manifested in the increase of potassium and decrease of sodium concentrations. Due to obvious reasons, the period of after-effect, determined by the measurement of potassium and sodium concentrations in the urine, was more prolonged.

Of special interest is the comparison of changes occurring in "elevations" to 5000 m and to 6000 m in persons who reacted well. As seen in Tables 1 - 4, an "elevation" to 5000 m was accompanied by more pronounced changes

than an "elevation" to 6000 m. Also, of note is the fact, that, while there were no cases of poor resistance among persons "elevated" in the barochamber to 5000 m, in 6000 m "elevations" approximately 25% of persons investigated showed a lowered resistance to hypoxia. The nature of changes in this group of persons was similar to that in the first barochamber "elevation" to 5000 m, but much more pronounced.

TABLE 4. Changes in Potassium and Sodium Concentrations in the Urine of Persons Who Reacted Well to a 15 minute "Elevation" to 6000 m

Sample	Concentration of sodium (mg%)	Concentration of potassium (mg%)	Ratio Na/K
First (before elev.)	518.8	226.1	2.7
Second	493.4	205.7	2.5
Third	485.2	200.7	2.6
Fourth	489.3	196.7	2.7
Fifth	482.1	203.5	2.6

TABLE 5. Changes in Potassium and Sodium Concentrations in Urine of Persons Who Showed Lowered Resistance to a 15 minute "Elevation" to 6000 m

Sample	Concentration of sodium (mg%)	Concentration of potassium (mg%)	Ratio Na/K
First (before elev.)	502.6	208.6	3.2
Second	499.6	245.2	2.2
Third	449.2	277.0	1.7
	t = 2.80	t = 2.94	t = 3.5
Fourth	453.0	201.7	2.4
Fifth	460.7	212.2	2.3

The levelling-off changes in the ionic equilibrium in persons who reacted well in 6000 m "elevations" could be explained, perhaps, by the adaptation of the organism to hypoxia, as a result of a preliminary "elevation" to 5000 m.

SUMMARY

The method of flame photometry was used for studying the sodium and potassium concentration in the saliva and urine of men "elevated" in a barochamber to the altitudes of 5,000 and 6,000 m. A definite regularity was noted in the shifts of concentration of the substances studied. The concentration of potassium ions has a tendency to rise, and that of sodium to drop. In repeated elevations these shifts become more regular.

LITERATURE CITED

1. M. A. Belogorskii, Nitrogen metabolism at lowered barometric pressure. Ph. D. Thesis, Makhach-Kala (1947).
2. G. E. Vladimirov, I. M. Dedyulin and G. F. Milyushkevich, Proc. of VI All-Union Convention of Physiologists, Biochemists and Pharmacologists (1937), p. 518.
3. I. I. Gorelov, Mineral content of blood under lowered atmospheric pressure. Thesis (1938).
4. I. M. Dedyulin, Acid-alkali equilibrium in the organism and respiratory function of persons under lowered atmospheric pressure conditions of variable duration. Ph. D. Thesis, Leningrad (1940).
5. A. J. Pratt, D. C. Smith and F. P. Ferguson, Endocrinology, Vol. 57, No. 4 (1955), p. 450.
6. E. S. Sundstrem and G. Shirogosints, Proc. XV International Congress of Physiology. Leningrad - Moscow (1935), p. 389.
7. E. S. Sundstraem and G. Michaels, Memor. of the University of California, Vol. 12 (1942), p. 409.