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THE EFFECT OF SMALL QUANTITIES OF FLUORINE ON THE HUMAN BODY

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SUMMARY: Clinical and physiological observations were made of school children in an endemic [area] where the fluorine content of water was within 1.6 mg/l. Stomatological examinations show that the prolonged use of drinking water containing these concentrations of fluorine causes among the children lesions of dental enamel of the I and II degree, and in individual cases those of III and IV degree. X-ray tests reveal an early synostosis in children suffering from endemic fluorosis. Besides, they presented a functional lability of nervous processes.

Experiments conducted on white rats show that fluorine administered in doses of about 1.0 mg/l causes a disturbance of the conditioned reflex activity.

Based on several studies, national standard GOST 2874-54 established the maximum allowable concentration of fluorine in drinking water to be 1.5 mg/l. However, this standard cannot be considered sufficiently substantiated. Despite the fact that fluorine exhibits strong neurotropic activity, the question pertaining to the functional state of the nervous system as a result of the long-term intake of fluorine in the drinking water has remained open. Moreover, several indications of endemic fluorosis development were observed in the population, even when using drinking water with fluorine concentrations below the standard recommended by GOST 2874-54 [S.N. Cherkinskaya, R.M. Zaslavsky, R.D. Gabovich, Smith, et al].

These considerations served as the basis for our studies,[1] aimed at substantiating the allowable level of fluorine in drinking water. In addition to animal experiments, we studied the nature of the impact of excessive and relatively low concentrations of fluorine on certain functions and systems of the human body.

We used the following research methods: a) hydro-chemical analysis of drinking water sources, b) dental examination of students, c) X-ray studies of bone formation processes in the students, d) physiological studies of the functional state of the higher parts of the central nervous system of the students, and e) an experimental study of the effects of different doses of fluorine on conditioned reflex activity of white rats in a chronic toxicological experiment (0.75, 0.075, 0.05 and 0.025 mg per 1 kg of body weight).

Artesian water containing up to 1.6 mg/l fluorine is used for domestic and drinking water supply in the endemic focal area. Some areas of the city, mostly around the perimeter, are deprived of running water, and the residents use well water. The fluorine content of the water from open wells does not exceed 0.14 mg/l. Children from the area comprised the control group.

To perform clinical and physiological studies, the required contingent was first selected from among pupils from the 3rd to 7th grade inclusive. The nature of their water use, duration of residence in the subject community, medical conditions, and dental examination data (fluorosis, dental caries) were taken into consideration. Essentially healthy students of both sexes, with normal physical development, were selected. Within the endemic focal area (fluorine content in water 1.6 mg/l), 1,755 students of both sexes received dental checkups.

30.7 percent of pupils suffer from endemic fluorosis of Stage I and 13 percent of Stage II. Even more pronounced cases were observed among some of the surveyed pupils (Stage III fluorosis in 7.7% and Stage IV in 0.9%).

[1] D.M. Kershenholtz, dentist, and Yu.A. Savvantova, chemist, took part in these studies

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The nature and characteristics of changes in the mineralized tissues resulting from the prolonged use of drinking water with excess fluorine are fairly well understood. At this time, substantial interest exists in the question of the influence of small amounts of fluorine on the skeletal system of a growing body. Given the inadequacy and inconsistency of the available information about the features of ossification in childhood when the body is exposed to low fluorine concentrations, we have designed our study in these terms. The ossification processes of the bones of the hands and distal forearm segment, observed on X-rays, provides insights into the pace of differentiation of the entire skeleton (V.G. Shtefko, 1947, et al). 192 students from the indigenous inhabitants of the area have been subjected to X-ray examinations.

Analysis of the X-ray material revealed no abnormalities in the sequence of either the appearance of ossification points or the onset of synostosis. However, regarding the synostosis timing, a tendency has been noted towards earlier onset of synostosis, compared to the control group, and to the generally accepted data reported in the literature. In schoolchildren affected by endemic fluorosis, the skeleton differentiation processes occurred earlier than the normal timing of ossification. This trend is manifested most clearly in the older age groups, starting with the age of 15. For example, in 18 of the 30 girls surveyed in the 15-16-year-old group, differentiation of the skeleton reached the phase normally corresponding to age 18-20. Analysis of X-rays of the hand in the 15-16-year-old schoolgirls of the control group shows the presence of cartilage layers between metaphyses and epiphyses of the short tubular bones and of the distal forearm segment (Fig. 1),

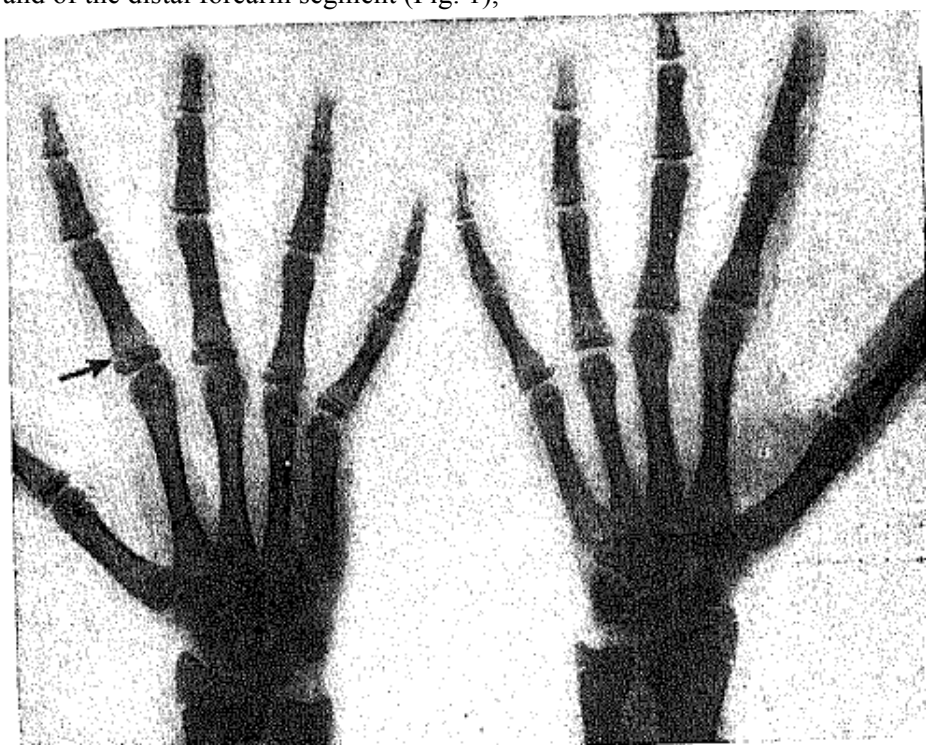

Fig. 1. X-ray image of both hands of a 15-year old school girl not affected by fluorosis (control group)

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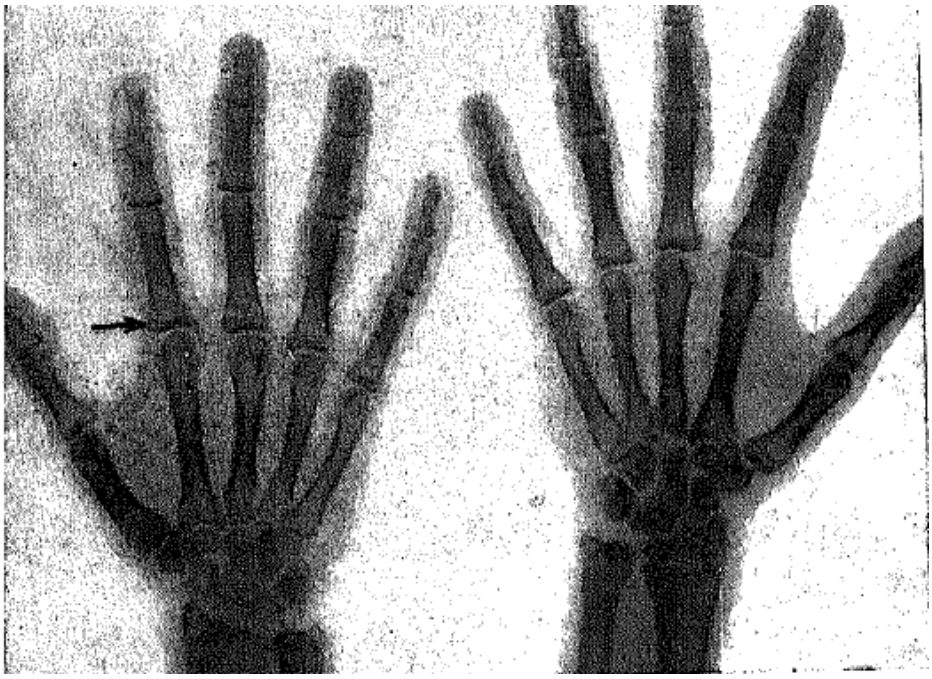

Fig. 2. X-ray image of both hands of a 15-year old school girl affected by fluorosis (main test group)

whereas the majority of schoolgirls in the same age group, affected by fluorosis, had no cartilage layer (Fig. 2). A similar pattern was observed among the examined boys as well, but they exhibited this trend to a somewhat lesser degree.

The functional mobility of neural processes has been judged on the basis of the oculomotor reaction speed readings, recorded by reaction meter designed by V.M. Abalakov.

Physiological studies have also been performed in the endemic focal area, where the fluorine content in the water does not exceed 1.6 mg/l. Observation was conducted on 110 students with symptoms of fluorosis.

Analysis of the data obtained in the study of students in grades 3-4 and 5-7 indicated some (statistically significant) reduction in functional mobility of neural processes in children affected by fluorosis. Extended latent oculomotor reactions dominated within this group of students. No connection has been revealed between the functional state of the nervous system and the clinical manifestations of fluorosis.

The dynamics of neural processes in the experiment under long-term (6-9 months) exposure of different concentrations of fluorine have been studied on white rats using the motor-alimentary technique developed by L.I. Kotlyarevsky. The experiment engaged 32 rats, allocated on the basis of the fluorine concentrations administered into the following groups: the control group (11 rats) and 4 test groups having received fluorine in an amount of 15 mg/l (3 rats), 1.5 mg/l (11 rats), 1 mg/l (7 rats), and 0.5 mg/l (4 rats).

Analysis of this material showed that the most profound breach of the conditioned reflex activity developed in white rats administered 15 mg/l fluorine. Lower amounts of fluorine (1.5 mg/l) also caused changes, primarily in the positive conditioned reflexes (elongated latent periods, decrease in magnitude of conditioned reflexes). In addition to the above, weakening of the internal inhibition processes and the development of protective inhibition has been observed. The statistical analysis completed confirmed the veracity of the results of experimental studies (see table).

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Status of the latent period dynamics in animals treated with fluorine (1.5 mg/l)

Number of animals	Duration of the latent period, seconds: initial background (M_1)	Duration of the latent period, seconds: the end of the first month of introduction of NaF (Al_2)	The value of t $t = \frac{M_2 - M_1}{m_{difference}}$	Statistical reliability
11	0.49	1.28	3.95	$p > 0.99$
11	0.49 (initial background)	1.50 (End of the chronic experiment)	6.3	$p > 0.999$

Generalization of the results of clinical, physiological and experimental research leads to the conclusion that low concentrations of fluorine in drinking water (1.5 mg/l) cause changes not only in the mineralized tissues (mottling of enamel, acceleration of synostosis processes), but also in the higher neural activity in humans and animals. Materials from our observations indicate that a fluorine concentration of 1.5 mg/l in the water is not indifferent to health. This has been noted by other authors as well (H. Strauss, G.N. Krasovsky, M.A. Roshal, et al). The clinical, physiological and experimental studies, as well as developments in the defluorination of drinking water, provide a basis for raising the question of reducing the hygienic standards for fluorine in drinking water, as recommended by GOST 2874-541.

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