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THE EFFECTS OF HIGH LEVELS OF FLUORIDE AND IODINE ON CHILD INTELLECTUAL ABILITY AND THE METABOLISM OF FLUORIDE AND IODINE

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SUMMARY: The authors carried out a study on the intellectual abilities and fluoride/ iodine metabolism of children living in a high fluoride-high iodine area. Among the results: the percentage of the general population living in this fluoride/iodine-contaminated region that suffered from goiter (clinical thyroid enlargement) was 3.8%, the rate of children already showing some thyroid enlargement was 29.80%. Similarly, the rate of dental fluorosis for the general population was 35.48%, while for children it was 72.98%. Student subjects had average IQs of 76.67±7.75, with 16.67% of the IQs in the "low" category. The iodine content and fluoride content of the children's urine were 816.25±1.80 µg/L and 2.08±1.08 mg/L, respectively, significantly higher than the control. The thyroid glands of the subjects showed a markedly lower uptake rate of iodine-131 when compared with the control, the values after 3 hr and 24 hr were 9.36±1.55% and 9.26±4.63%, respectively, and the blood serum levels of thyroid stimulating hormone (TSH) were significantly higher than the control. The results indicate that high levels of fluoride and iodine have a serious damaging effect on the body, and should be given greater attention.

Keywords: Child IQ; Dental Fluorosis; High fluoride water; High iodine intake; Iodide Goiter; Thyroid Stimulating Hormone.

INTRODUCTION

The subjects of this study were residents of the Huimin and Dezhou regions of Shandong Province located on the lower reaches of the Yellow River. In 1976, in a response to increasingly bitter, salty water, much deeper wells were dug. However, the fluoride and iodine content of this deep well water was found to be much higher than the standards for drinking water, resulting in a high prevalence of iodine goiter and fluoride poisoning. The area is known locally as the "twin contamination zone." In order to investigate the effects of high iodine and fluoride on child intellectual ability and the metabolic characteristics of iodine and fluoride, we carried out a comparative study of two villages in Qingyun County with the following results.

MATERIALS AND METHODS

1. Lidian village of Qingyun County was selected as the site of our study; its drinking water was tested to have an iodine content of 1,100 µg/L and a fluoride content of 2.97 mg/L. The non-disease control was Dading village of the same county; its drinking water showed an iodine content of 128.6 µg/L and a fluoride content of 0.5 mg/L.

2. The diagnoses of goiter and dental fluorosis were both carried out according to national standards for endemic disease control.[1,2] Intelligence testing was done using the Chinese Comparative Scale of Intelligence Test (Third Edition), as revised by Wu Tianming.[3]

3. The determination of iodine and fluoride levels in the drinking water was accomplished by conventional physicochemical analysis techniques, with their values expressed in units of µg/L and mg/L, respectively. The incineration method was used to determine urinary iodine, again expressed as µg/L, while the electrode

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method was used for urinary fluoride, expressed as mg/L. The measure of the thyroid gland absorption rate of iodine-131 was done on site using a type 44-1 thyroid function indicator from the Hefei Wireless Electronics Factory. T_3, T_4, and thyroid stimulating hormone (TSH) were measured using radioimmunoassay.

RESULTS

I. Rates of goiter and dental fluorosis:

1. The prevalence of goiter and dental fluorosis in the studied populations are shown in Table 1.

Table 1. Comparison of the number of cases of thyroid gland enlargement and dental fluorosis in the endemic and control groups

Group	Sample size	Thyroid gland enlargement			Dental fluorosis	
		No. with physical swelling	Clinical goiter cases	Disease rate (%)	Clinical cases	Disease rate (%)
Endemic	1102	217	42	3.80	391	35.48
Control	416	42	2	0.48	57	13.7
				P<0.01		P<0.01

As seen in Table 1, the subject-study group ingesting water with high levels of fluoride and iodine show significantly increased disease rates for goiter and dental fluorosis when compared with the control group, and the rates are sufficient to classify these diseases as endemic to the area.

2. For children 15 or younger, the rate of thyroid swelling was 29.8% (96/322), and the rate of dental fluorosis reached 72.98% (235/322). In the control group, the rates were 16.13% (15/93) and 18.28 (17/93), respectively, with $P<0.01$ in all cases, indicating that the harm caused by a high fluoride-high iodine environment is particularly serious in the case of children.

II. Intelligence testing for 8–14-year-old children:

The average IQ scores of children in the high fluoride, high iodine area and the control area were 76.67±7.75 and 81.67±11.97, respectively. This difference is not statistically significant; however, as seen in Table 2, the number of children showing moderately low IQ scores in the subject population is significantly higher than the control.[b]

III. Urinary iodine and urinary fluoride test results:

As seen in Table 3, the school-age children in the endemic region have urinary iodine and urinary fluoride levels significantly higher than in the control group ($P<0.01$), indicating that they are absorbing large quantities of iodine and fluoride from the drinking water, and that the body load of these two substances is high.

IV. Thyroid gland iodine absorption rate of children in the two groups:

When tested after 3 and 24 hr, the average values of the thyroid gland iodine-131 uptake rate for children in the endemic disease area was 9.36±1.55 and 9.26±4.63%, respectively, which are significantly lower than the averages of the control area of 13.34±2.88 and 22.79±5.29% ($P<0.01$). The nearly identical values at 3 and 24 hr

[b]***Editorial comment:*** The number of subjects in the <69 IQ groups (5/30 vs. 3/30) are too small for reliable statistical analysis. When the children in the two lowest IQ groups are combined (5 + 18)/30 = 23/30 vs. (3 + 8)/30 = 11/30) the result is statistically significant by the appropriate chi-square test (with the Yates correction): chi-square, $\chi^2 = 8.22$, $P<0.01$.

after exposure in the endemic area group suggest a backwards shifting of the peak value.

Table 2. IQs and the IQ distribution (%) for children in the endemic endemic and control groups

Group	n	Average IQ	<69	70-79	80-89	90-100
Endemic	30	76.67±7.75	16.67	60.00	6.67	16.66
Control	30	81.67±11.97	10	26.67	40.00	23.33
		P > 0.05				

Table 3. Average urinary level of iodine and fluoride of school-age children within the two groups

Group	Urinary iodine (μg/L)		Urinary fluoride (mg/L)	
	n	Mean±SD	n	Mean± SD
Endemic	25	818.25±1.80	23	2.08±1.03
Control	29	212.04±1.95	27	0.82±0.56
		P<0.01		P<0.01

V. Blood serum hormone levels:

As shown in Table 4, there was a general increase in the average levels of T_3, T_4, and TSH in children from the endemic area compared to the controls. However, only the TSH value was significantly higher (P<0.01).

Table 4. Comparison of blood serum hormone levels

Group	T_3 (μg/dL)		T_4 (ng/dL)		TSH (μIU/mL)	
	n	Mean±SD	n	Mean±SD	n	Mean±SD
Endemic	23	0.76±0.36	24	147.83±88.31	4	3.37±2.16
Control	33	0.74±0.43	33	128.46±38.12	10	0.82±0.51
		P>0.05		P>0.05		P<0.01

DISCUSSION

Iodine is a necessary trace element for organic life, and fluoride is similarly regarded, but if the ingestion level is too high or too low, especially for iodine, disease is the result. In this study, the prevalence of goiter in the subject population from a high iodine-high fluoride village area was 3.8%, with thyroid swelling present in 29.81% of the children age 15 and under. In addition, the rate of dental fluorosis in the endemic study population was 35.48%, reaching 72.98% in the children age 15 and under. In all cases the rates for the endemic group were significantly elevated compared to the control group. This suggests that the separate harm caused by an excess of each of the two elements is compounded when iodine and fluoride occur together in a single region, with their ingestion leading to a serious array of health problems.

An excess of fluoride and a lack of iodine in the same environment has been shown to have a marked effect on child intellectual development, causing a more significant intellectual deficit than lack of iodine alone.[4] In our study the study group of children from the high fluoride-high iodine village area had an average IQ of 76.67±7.75,

which was somewhat lower than the control (IQ 81.67 ±11.9), although the difference is not statistically significant (P>0.05). However, as seen in Table 2, the percentage of children in the low range (16.67%) is higher in the endemic group than in the control group (10.0%), suggesting that a high iodine-high fluoride environment also has a definite negative influence on child intellectual ability.[c]

The urinary iodine and urinary fluoride levels for children living in the high iodine-high fluoride area were 816.25±1.80 μg/L and 2.08±1.03 mg/L, respectively, clearly elevated by comparison to the control, reflecting the high body load of iodine and fluoride. Elemental iodine is a key component of thyroid hormones, and also influences several stages of their formation and excretion.[5] Fluoride, on the other hand, is toxic to living cells, and is a powerful inhibitor of certain enzymes. Excessive uptake of fluoride can cause decreased functioning of the thyroid gland in direct relation to the blood level. Of course, iodine is the primary factor here; what exact role that fluoride is playing requires further study.

The serum levels of T_3 and T_4 for the children from the high iodine-high fluoride zone were only slightly higher than the control (P>0.05), but the level of TSH was clearly elevated (P<0.01). That the thyroid gland excretion of T_3 and T_4 for the "twin contamination zone" children was in the normal range, but the pituitary gland secretion of TSH was significantly elevated making it probable that reverse feedback is promoting the hypothalamus excretion of TRH (thyroid releasing hormone), causing a corresponding increase in the excretion of TSH, which stimulates compensating production of T_3 and T_4 by the thyroid gland.

In summary, the results of this study indicate the following:

(1) Areas that have long-term, serious iodine and fluoride contamination can cause goiter and fluoride poisoning in the population; this problem should be taken seriously.

(2) The clinical characteristics of children from this region include high urinary iodine, high urinary fluoride, poor thyroid iodine-131 absorption with similar values at 3 and 24 hr (possibly a backward peak value shift), and high TSH values.

(3) With regard to the diseases endemic to this high iodine-high fluoride zone, the only fundamental means of control is to change the source of water, limit the ingestion and absorption of iodine and fluorine, and promote their excretion from the body.

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[c]An editorial comment on the statistical testing is given as a footnote on p. 337.