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RESEARCH ON THE INTELLECTUAL DEVELOPMENT OF CHILDREN IN HIGH FLUORIDE AREAS

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[SUMMARY: As measured by the rural version of the Chinese Standardized Raven Test, the average IQ of 320 children conceived and raised in the village of Biji, Linyi County, Shanxi Province, with 4.55 mg F/L in the drinking water, was 100.24±14.52. The average IQ of the same number of children conceived and raised in the control village of Jiaobei in the same county with 0.89 mg F/L in the drinking water was significantly higher at 104.03±14.96 (p<0.01). Higher rates of dental and skeletal fluorosis were found in Biji than in Jiaobei. Although the two villages have essentially the same cultural, occupational, health care, and life-style characteristics, higher IQs of the children were associated with higher levels of parental employment and education.]

[Keywords: Biji village; Children's IQ; Chinese Raven test; Jiaobei village; Linyi County, Shanxi Province, China.]

INTRODUCTION

Fluoride can pass through the placental barrier and accumulate in brain tissue, possibly influencing intellectual development after birth.[1] Research reports on this topic, however, are not entirely consistent. In order to further investigate the effects of fluoride on intellectual development, the authors used the rural version of the Chinese Standardized Raven Test[4] to carry out a study on the intellectual ability of 640 children living in the endemic fluorosis village of Biji and the non-endemic control village of Jiaobei (both in Linyi County, Shanxi province), who were born before the drinking water was changed.

SUBJECTS AND METHODS

Choice of location:

(i). The residents of the endemic area, Biji village, drink high fluoride water (fluoride content 4.55 mg/L) year round; the rate of dental fluorosis is 85%, and the rate of skeletal fluorosis is 25%.

(ii). The drinking water of the control area, Jiaobei village, has a fluoride content of 0.89 mg/L; the rate of dental fluorosis is 15%, and there are no cases of skeletal fluorosis. By every other comparison (i.e., occupations, cultural level, standard of living, lifestyle habits, access to health and transportation facilities, etc.) the two villages are essentially the same.

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Basis for the choice of test subjects:

(i). The mother of each subject must have resided in the village under investigation while pregnant (i.e. while the subject was in the fetal phase of development). From each age group, 40 children were randomly selected to be subjects, with equal numbers of boys and girls.

(ii). Method for calculating test subject age: The difference between the testing date and the birth date on the household residence card was calculated; a remainder of more than 15 days was rounded up to the next month, a remainder of less than 15 days was rounded down to the date month.

Testing method:

Before the testing, three doctors were selected to oversee the procedure and were rigorously trained. Test results were scored according to the unified seven ranking standard.

RESULTS

Average IQs of the tested children in the endemic area and control:

The 320 children from Biji village who had been exposed to fluoride since they were in the fetal stage showed an average IQ of 100.24±14.52; the 320 children from Jiaobei village, the control, tested with an average IQ of 104.03±14.96. The average IQ of the subjects from the endemic area was lower than the control, and a statistical analysis demonstrates that the result is very significant ($t = 3.24$, $p<0.01$). There is no statistically significant difference in the average IQ difference between the genders in either group (see Table 1).

Table 1. Comparison of the IQs of 7–14 year old children in the endemic and control areas

Test area	n	IQ range	Average IQ ± Standard Deviation		
			Boys	Girls	Total (boys & girls)
Endemic	320	50–137	100.43±14.58	100.01±14.58	100.24±14.52
Control	320	77–146	104.73±15.31	103.45±14.47	104.03±14.98

Distribution of intellectual ability in the endemic area and the control:

The IQs of most of the 7–14 year old children from both the endemic area and the control area were in the average or above average range, but among the 320 children in the high fluoride area there were two children, or 0.60%, whose IQ was lower than 69, which classifies them as being intellectually underdeveloped. There are no children from the control group that fall into the intellectually underdeveloped range. In the endemic area, children in the excellent or outstanding range make up 9% of all the children tested, whereas in the control area 15% of the children are classified as excellent or outstanding (see Table 2).

Table 2. The distribution of IQ scores for 7–14 year old children in the endemic and control areas

IQ	Endemic area				Control area			
	Boys (n)	Girls (n)	Total (boys & girls, n)	%	Boys (n)	Girls (n)	Total (boys & girls, n)	%
>130	3	2	6	1.80	7	7	14	4.37
120–129	11	12	23	7.10	20	13	33	10.31
111–119	38	34	72	22.50	43	39	82	25.63
90–109	65	75	140	43.70	58	74	132	41.25
80–89	31	25	56	17.50	23	20	43	13.44
70–79	12	10	22	6.80	9	7	16	5.00
<69	0	2	2	0.60	0	0	0	0.00
Total	160	160	320	100	160	160	320	100

Comparison of the endemic area and the control area by age group:

In Table 3, the 7–14 year olds are divided into smaller age groups, and for nearly every age group the average IQ of the children from the endemic area is lower than the control. The IQs of both groups show a general tendency to increase as age increases.

Table 3. Comparison of the IQs of endemic and control area children by age group

Age (years)	Endemic area IQ (average±SD)	Control area IQ (average±SD)
7	90.03±11.44	94.15±12.06
8	92.01±11.76	101.33±16.22
9	98.96±14.66	99.48±11.51
10	98.90±15.90	104.14±17.34
11	100.68±11.49	101.65±14.16
12	100.55±12.28	107.39±14.08
13	114.40±12.57	109.63±14.22
14	106.38±10.33	114.52±9.90

Relationship between child IQ and parental occupation and educational level in the two regions:

This study revealed that the IQ of the children in both areas was correlated with the occupation and educational levels of their parents. The IQ of children born into an "employed" household (i.e., where one or both parents is an employee) was significantly higher than those born into a household with farming parents: in the endemic area, child IQs with employed parents n = 74, = 104.54; control area, child IQs with employed parents n = 77, = 108.91; endemic area, child IQs with farming parents n = 246, = 98.86; control area, child IQs with farming parents n = 243, = 99.60. IQ also increased with the level of the parent's education: in the endemic area, child IQs with parents who went to high school n = 130, = 100.88; middle school n = 150, = 98.83, elementary school n = 38, = 93.02; in the control area, child IQs with parents who went to high school n = 150, = 106.90; middle school n = 158, = 101.97; elementary school n = 31, = 89.45. Both sets of results are statistically significant ($p<0.01$)

DISCUSSION

The results of this study indicate that there is significant difference between the intellectual ability of the 7–14 year old children in the endemic area and those in the non-endemic control area, and, moreover, the average IQ of the children in the endemic area is clearly lower than in the non-endemic area. In the endemic region, the children in the 80–89 IQ range and below make up more than 25% of the total, while in the control area only 18% of the children fall into this range, demonstrating that high fluoride has a direct connection with the intellectual development of children.

The reasons for this include:

(i) Fluoride causes a retardation of the development of nerve cells in the cerebral cortex, with relatively poor differentiation, and fewer mitochondria, microtubules, and vesicles in the synapses as well as fewer synapses in general,[1] possibly leading to fewer connections between neurons and abnormal synapse function, ultimately affecting the intellectual development of the fetus after birth.

(ii) Zhou Zhenlong et al.[5] report that activation of acetylcholinesterase in the blood of fluoride poisoned patients is clearly reduced as compared to healthy control, while the levels of acetylcholine in the fluorosis sufferers were clearly elevated by comparison to the control. Quan Wu et al.,[6] while doing research on rats to determine the effects of chronic fluoride poisoning on the anterior horn of the spinal cord, skeletal muscle fiber, and their endplates, saw, under the microscope, that fluoride had an obvious damaging effect on nerve tissue, and that this occurred prior to skeletal constriction. A major facet of this damage was the effect on the nerve cell, i.e., the direct harm done to the cells of the anterior horn, while the other facet was the effect on the enzymes that participate in nerve impulse transmission, for instance the inhibiting activation of acetylcholinesterase.

These reports indicate that excessive intake of fluoride can inhibit the physiological function of various kinds of enzymes, leading to disruption in the metabolism of the organism and overall physiological dysfunction. This in turn affects high-level activity in the nervous system, inhibiting cholinesterase, and causing a breakdown in nerve impulse transmission.

Many factors influence intellectual ability. Besides the major influence of a high fluoride environment, the occupation and education of the parents also appears to play a definite role. Our study found that the IQs of children born into an "employed" household was higher than those born into a farming household, and that the IQ levels of the children increased along with the education level of their parents. This correlation indicates that a positive educational influence from the family is a benefit to child intellectual development. Therefore, strict uniformity requirements must be enforced when selecting an area for study, determining the test subjects, etc. Only then will the effects of high fluoride (or other experimental factors) be visible for objective investigation. The present study paid special

attention to this aspect; the occupations and education levels of the children's parents were basically the same in both the endemic and control area.

Previous studies of child intelligence have mainly made use of the Binet-Simon intelligence test or the Wechsler scale of intelligence. These two intelligence tests are both fairly time-consuming, and are limited by certain pre-requisites. This study used the rural version of Chinese Standardized Raven Test, which has the advantage that there are no limits placed on the children in terms of education, culture, or language, and it can also be used on the deaf and mentally-handicapped. This test can be carried out individually or in a group, is generally easy to use, saves time and energy, and the explanation of the results is simple and direct. With these advantages, it is especially well suited to use in rural areas and for the testing of intellectual ability related to investigation of epidemic diseases.

REFERENCES

1 He Han et al. The effects of fluoride on the fetus. Chinese Journal of Control of Endemic Diseases 1989;4(3):136.
2 Hu Yunsen et al. Research study on the IQ levels of Six- to Fourteen-year-old School-age Children Living in an Area with Local Fluoride Poisoning. Collection of Academic Papers and Abstracts from the First Meeting of the Chinese Fluoride Research Association 1989;6:73.
3 Ren Dali et al. A study of the intellectual ability of 8–14 year-old children in high fluoride, low iodine areas. Chinese Journal of Control of Endemic Diseases 1989;4(4):251.
4 Wang Dong et al. Chinese Standardized Raven Test, Rural Version. 1989.
5 Zhou Zhenlong et al. Research on the effects of aragonite on the activation of acetylcholinesterase and the levels of acetylcholine in the blood of skeletal fluorosis sufferers in China. Chinese Journal of Endemiology 1986; 5(1): 262.
6 Jin Wu et al. The effects of chronic fluoride poisoning on the cells of the anterior horn of the spinal cord, the skeletal tissue fibers and their moving endplates in rats. Chinese Journal of Control of Endemic Diseases 1989;4 Suppl:69.