Investigation on children's growth and development under long-term fluoride exposure

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[Abstract] **Objective** To study the influence on children's growth by long-term high fluoride exposure. **Methods** Case group was selected in high fluoride areas and control group was selected in non-high fluoride areas. The difference of children's growth levels were analyzed between 2 groups. **Results** The IQ of case group was significantly lower than that of control group (t = 2.621, P<0.01) and it was negatively correlative with the concentration of children's urinary fluoride in a certain extent (r = -0.119, P<0.05). Children's heights and weights of case group were significantly lower than those of control group (t = 2.621, P<0.01 ^{u} = 3.515 P < 0.01). Conclusions Long-term fluoride exposure can affect children's growth and development. In order to protect children's health measures of prevention and treatment should be adopted.

[Keywords] Fluorides, Poisoning, Intelligence, Growth and development

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Endemic fluorosis is a biogeochemical disease that causes serious harm to physical health, not only causing damage to teeth and bones, but also leading to non-skeletal damage. The population living in endemic areas in China currently amounts to 112 million people, including 40.6 million people with dental fluorosis and 2.6 million people with skeletal fluorosis. One aspect that cannot be ignored is the health problems it causes for children in these affected populations. Children are still in the stage of growth and development, and so they are highly susceptible to the effects of harmful substances in the external environment, while their bodies are extremely vulnerable to damage. In this investigative study, we collected data on the growth situations of children in high fluoride areas by looking at the quantitative and qualitative changes of their growth and development, which allowed us to shed further light on the extreme pathogenic mechanisms of the systemic toxic damage caused by fluorides in the bodies of children. This will also provide scientific evidence for early diagnosis, dynamic monitoring, and risk assessment and for proposing targeted measures for prevention and treatment.

1 Subjects and Methods

1.1 Investigation subjects

We selected Linyi County of Yuncheng City in Shanxi Province, an area severely affected by fluorosis, and we also selected a non-high fluoride area in a nearby region as the control group to use as a comparison for the growth and development situations of children.

1.2 Contents and indicators

1.2.1 We conducted tests of the intelligence and of the growth and development of children aged 8 to 12 attending school in the two groups. We also did tests of fluoride content in all sources of drinking water. We randomly chose the urine samples of a certain number of children in each age group to do testing for fluoride in urine.

1.2.2 Intelligence testing: We tested and scored following the method of the "Combined Raven's Test for Rural China" (CRT-RC) and arrived at the intelligence quotients (IQ) by applying a norm based on the scores. In terms of IQ classifications, we classified ≤69 as low, 70 to 79 as borderline, 80 to 89 as low average, 90 to 109 as average, 110-119 as high average, 120 to 129 as superior, and ≥130 as very superior.

1.2.3 Growth indicator testing: The main indicators reflecting the growth levels of children were the three morphological indicators of height, weight, and chest circumference. To control testing quality, strict training of the testing personnel was provided before the testing according to the related requirements of child growth indicator testing. [1]

1.2.4 The method of fluoride ion selective electrode analysis was used to test the fluoride values in drinking water and urine.

1.2.5 The SPSS10.0 for Windows and CS2000 statistical software package was used for data processing and analysis.

2 Findings

2.1 Fluoride exposure level of children

As shown in Table 1, there was a statistically significant difference between the levels of fluoride in the urine of the two groups of children (u=12.811, P<0.01). The drinking of high-fluoride water for long periods of time by children in the high fluoride area caused the level of fluoride in the urine to rise higher.

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Table 1 Results of testing fluoride content in children's drinking water and urine (mg/L)

Group	Fluoride in water		Fluoride in urine	
	n	x̄ ± s	n	G ± s
High fluoride group	9	5.54 ± 3.88	215	5.50 ± 2.40
Control group	6	0.73 ± 0.28	147	1.51 ± 1.66

2.2 IQ levels and distributions in children of the high fluoride area and control group

As shown in Table 2, the IQs of children in the control group were higher than those of the high fluoride area, and the difference was statistically significant (t=2.621, P<0.01). In terms of the IQ classification constituent ratio, the children of the high fluoride group were made up of 21.29% at the superior and very superior IQ levels, while the children from the control group were made up of 33.14% at the superior and very superior IQ levels, a difference that was statistically significant (χ^2=6.54, P<0.05). The average IQ level of the children in the high fluoride group was 3.67% lower than that of the children in the control group.

Table 2 IQ levels and distributions of children of the two groups

Group	n	IQ (x̄ ± s)	≤69		70-79		80-89		90-109		110-119		120-129		≥130	
			n	%	n	%	n	%	n	%	n	%	n	%	n	%
High fluoride group	202	107.46 ± 15.38	3	1.49	6	2.97	19	9.41	75	37.13	56	27.71	35	17.33	8	3.96
Control group	166	111.55 ± 15.19	1	0.60	2	1.20	13	7.83	55	33.13	40	24.10	35	21.09	2	12.05

2.3 Relationship between IQ and fluoride in urine

In regions with drinking water-related fluorosis, the fluoride in urine can be used to indirectly reflect the body's level of fluoride intake, which has a positive correlation with the fluoride in water. We did a rank correlation analysis of the IQ levels and the levels of fluoride in urine of the children of the two areas and found that there was a negative correlation between IQ level and the level of fluoride in urine (r=-0.119, P<0.05).

2.4 Growth indicators of children

To exclude the influencing factors of gender and age on height, weight, and chest circumference, we used the z-score method, [2] using as the reference standard the mean and the standard deviation of the morphological indicators of children aged 8 to 12 from Shanxi Province taken from the findings of the "2000 Chinese Student Physique and Health Survey." [3] We did standardization for gender and age to come up with the z values and did a comparison of the overall levels of the two groups, with the results shown in Table 3.

Table 3 Comparison of growth morphological indicators of the children aged 8 to 12 of the two groups (x̄ ± s)

Group	n	Height z value	Weight z value	Waist size z value
High fluoride group	221	-0.65 ± 1.05	-0.14 ± 0.95	-0.26 ± 0.82
Control group	173	-0.36 ± 1.10	0.13 ± 0.96	-0.20 ± 0.85

We did a comparison using the differences between the groups in terms of the morphological indicators of height, weight, and chest circumference of the high fluoride group and the control group and found a significant difference for height and weight, which were both higher for the high fluoride group compared to the control group (t=2.621, P<0.01; u=3.535, P<0.01). There was no difference found for chest circumference (u=0.571, P>0.05).

3 Discussion

Fluoride is a protoplasmic toxin that can easily penetrate the cell membranes of all types of tissue and enter into cells, which causes damage to normal cellular functions. High levels of fluoride can enter brain tissue through the blood-brain barrier and produce a toxic effect on neurons, which causes brain injury. [4] Li Jing *et al*. [5] investigated the neurobehavioral development of newborns in high fluoride areas and discovered that the high fluoride intake of pregnant mothers in their living environments could produce an adverse influence on the neurobehavioral development of newborns. They also found that active muscular tension development in newborns was influenced. Active muscular tension is an indicator of motor function development, and its abnormality may indicate brain injury. Behavioral capacity and active muscular tension are very closely related to long-term psychomotor function; therefore, some of the data reported in recent years [6, 7] has shown a lowering of the IQ level in children in fluorosis endemic areas. In our study, the other external environmental factors of the high fluoride area group and the control group were basically consistent, but there was still a clear difference in IQ. This further proves that the cause was the high fluoride environment. There is still room for more in-depth investigation of how serious the influence of a high intake of fluoride is on IQ.

Animal experiments [8] have clearly shown the potential harm that fluoride can do to mice offspring, which is expressed in the retarded physical development and neurobehavioral development of the offspring after birth. Onsite epidemiological investigation data [9, 10] shows that the influence of fluoride on the growth and development of children is comprehensive, influencing the morphology, functions, bones, and teeth to different degrees. The influence of high fluoride intake on the growth of adolescents is even more obvious. Height is the most characteristic indicator of growth and development, and weight can reflect the state of nutrition and the development situation of bones and muscles to a considerable extent. We can see from the findings of our study that there is a clear difference in terms of the height and weight of the high fluoride group and the control group, which provides further evidence that fluoride produces a certain hazard for the morphological development of children.

Growth refers to the changes of a child in terms of overall body size, length, weight, and body composition. Development refers to constant psychological, intellectual, and physical development. This investigation selected representative indicators in these two areas for a comprehensive study, and the conclusions that were reached leave no room for doubt. Considering the harm that fluoride can do to the growth and development of children, we should place a high degree of importance on the health care of children living in high fluoride areas, intensifying the efforts to improve drinking water quality and strengthening the level of nutrition in the diet. We should proactively take comprehensive prevention and treatment measures to reduce bodily absorption of fluoride and to promote the excretion of fluoride from the body, further raising the quality of the population as part of promoting the constant development of society and the economy.

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