Comparative Assessment of the Physical and Mental Development of Children in an Endemic Fluorosis Area with and without Water Improvement Programs

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Abstract: Tests were performed to compare the IQ and physical development of 7-to-14-year-old children from endemic fluorosis areas, with and without water improvement programs, with children from a non-fluorosis area. The results showed that the average IQ of children in each age group from the fluorosis area without water improvement is lower than those from either the fluorosis area with water improvement or the non-fluorosis area ($P<0.01$). When comparing 7-to-8-year-old children born after the implementation of the water improvement program to children of the same age group in the non-fluorosis area, no obvious difference was found. Comparisons of the height, weight, and sitting height of children in the fluorosis area without water improvement and the fluorosis area with water improvement revealed an obvious difference for the 12-to-14-year-old age group. No obvious differences were found between the fluorosis area with water improvement and the non-fluorosis area. These results show that water improvement and defluoridation can improve the mental and physical development of children in a fluorosis area.

Keywords: Endemic fluorosis, IQ, Physical Development, Children

The effect of endemic fluorosis is not limited to dental and skeletal fluorosis. A number of studies in China have established that high fluoride exposure may also impact childhood mental and physical development. [1,2] A question worth exploring, therefore, is how water improvement and defluoridation programs to prevent fluorosis may improve the physical and mental development of children. It is important that research comprehensively assess this question. In September 1994, we began an investigation and the results are as follows.

1. Materials and Methods

1.1 Location and Subjects

Among the endemic fluorosis areas in Chaoyang City, Wujiawa village was chosen as the fluorosis area with a water improvement program as it has been using low fluoride water for eight years. Mangniuying village was chosen as the fluorosis area without water improvement. The prevalence rate of dental fluorosis in these two fluorosis areas are basically the same: the dental fluorosis rate among 8 to 15 years old children in Wujiawa village before the water improvement was 88.85%; in Mangniuying village, the rate is 86.10%. The fluoride level in the drinking water for both areas was 2.0 mg/l until Wujiawa village reduced its level to 0.33 mg/L with the implementation of the water improvement program. Yi village elementary school, where the fluoride level in the drinking water is 0.4 mg/L, is a non-fluorosis area and was chosen as the control group.

The subjects in each of the three areas selected are 7-to-14-year-old children, all of whom were born locally, with half of them boys and half of them girls. Both the fluorosis areas (with and without water improvement) and the non-fluorosis area have iodine deficiency disorders under control; the urinary iodine of the residents is 131.5 mg/L. The level of economic development and living, the size of school, the number of teachers, and the condition of iodine nutrition are all basically the same among the three areas.

1.2 Measuring Methods

The Raven's Standard Progressive Matrices (China's Rural Version) was used as the intelligence test, with the time of the test limited to 40 min. The results are represented in terms of IQ. Physical development indicators (height, weight, sitting height and the chest circumference) were all measured by a unified standard. The weight measurements were accurate down to the 0.1 kg level, and the height, sitting height, and chest circumference measurements were accurate to the 0.1 cm level.

1.3 Statistical Methods

The measurements are all shown in mean, standard deviation, and statistical significance (means adopted t test).

2. Results and Analysis

2.1 Intelligence Tests

Intelligence tests of the 326 children aged 7-to-12-years-old in the fluorosis area with water improvement showed the average IQ to be 97.83±11.27. The 183 children from the fluorosis area without water improvement had an average IQ of 94.89±11.15 and the 314 children from the non-fluorosis area had an average IQ of 99.98 ±12.21. The IQ of the fluorosis area without water improvement was obviously lower than both the fluorosis area with water improvement and the non-fluorosis area (t=2.85, 4.67; P<0.01), and the IQ of the non-fluorosis area was higher than the fluorosis area with water improvement (t=2.31, P<0.05). As to the average IQ of each particular age group, the fluorosis area without water improvement was lower than both the fluorosis area with water improvement and the non-fluorosis area (P<0.01). The differences in IQ between the 7-to-8-year-old children in the fluorosis area with water improvement and the non-fluorosis area were not obvious (t=0.09, P>0.05). Among the 9-to-12-year-old children, however, the average IQ in the fluorosis area with water improvement was lower than the non-fluorosis area (P<0.01), see table 1.

2.2 Physical Development Measurements

1100 children from the fluorosis areas with and without water improvement and the non-fluorosis area were measured to assess 4 morphological indices. There was no obvious difference in chest circumference among the three groups (P>0.05), while the indices of height, weight, and sitting height of each age group from the fluorosis area without water improvement were lower than that of the fluorosis area with water improvement and the non-fluorosis area; the height was 1.1-6.3 cm lower than that of the fluorosis area with water improvement; the weight was 0.7-3.8kg lower; and the sitting height was 0.3-4.6cm lower. The age group that had obvious differences in height and weight was the 12-to-14-year-olds, and the age group that had obvious differences in sitting height were the 14-year-olds. No obvious differences among each index and each age group (P>0.05) were found when comparing the fluorosis area with water improvement and the non-fluorosis area, see table 2, 3, 4.

3. Discussion

Since the absorption rate of fluoride among children is higher than adults, the effects and harm of high fluoride on the growth and development of children cannot be neglected. As reported in previous research, the weight

Table 1: IQ comparison of children in different age groups in different areas

Age (years old)	Fluorosis Area with Water Improvement		Fluorosis Area without Water Improvement		Non-Fluorosis Area	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
7	98.4	11.5	95.8	10.3	98.1	12.2
8	99.1	10.6	95.4	11.5	99.2	9.6
9	99.0	11.3	94.6	11.3	102.8	10.2
10	98.0	12.2	93.2	10.6	101.3	11.2
11	98.9	11.4	92.1	11.3	98.3	11.6
12	96.7	10.7	93.4	12.1	99.5	12.2

of the brain among 6-year-old children is about 1,200g, which is 90% of the respective weight in adults [3]. Therefore, the pre-6-year-old period is a critical one for children's mental development. Drinking water with high fluoride content during this time thus has a significant impact on the intelligence development of children. In this survey, the IQ of two groups of children, who were 7 or 8 years old and were born after drinking low fluoride water, was not obviously different from the IQ of children from the non-fluorosis area. This is mainly because the children of this age group have always been drinking low fluoride water and have not been exposed to high fluoride. By contrast, since the water improvement program was implemented 8 years ago, the children who are currently 9-to-12-years-old were exposed to a high fluoride environment either in the fetal period in the womb or within the four years after birth. Although they are now drinking low fluoride water, they have been exposed to various levels of fluoride harm during the critical period of childhood brain development and their mental development has been influenced to a certain degree. As a result, their current IQ is still lower than that of the non-fluorosis area.

The results of measurements of morphological indices showed that the height, weight and sitting height of children in the fluorosis area without water improvement were lower than the groups from the fluorosis area with water improvement and the non-fluorosis area. The age group that had obvious differences was mainly the 12-to-14-year-olds, which indicates that this age group is at the second rapid growth period for children's growth and development. High fluoride delays and postpones the growth and development of children. Comparing the chest circumference among the three groups, there was no obvious difference, which indicates that high fluoride exposure had little effect on the development of chest circumference.

Table 2: Comparison of height of children in different age groups in endemic fluorosis area with and without water Improvement (cm)

Age (years old)	Fluorosis Area with Water Improvement			Fluorosis Area without Water Improvement			Non-Fluorosis Area		
	No. of children	Mean	Standard Deviation	No. of children	Mean	Standard Deviation	No. of children	Mean	Standard Deviation
8	144	121.9	1.8	64	120.8	3.1	168	122.8	3.7
10	138	132.6	3.1	46	131.4	3.2	166	132.8	3.4
12	72	143.7	3.6	62	139.6	2.8	198	144.2	3.9
14	14	152.8	2.3	16	146.5	3.2	22	153.5	3.4

Table 3: Comparison of weight of children in different age groups in endemic fluorosis area with and without water improvement (kg)

Age (years old)	Fluorosis Area with Water Improvement			Fluorosis Area without Water Improvement			Non-Fluorosis Area		
	No. of children	Mean	Standard Deviation	No. of children	Mean	Standard Deviation	No. of children	Mean	Standard Deviation
8	144	23.9	1.5	64	23.2	1.9	168	24.5	1.6
10	138	28.1	2.3	46	27.3	2.1	166	29.0	1.9
12	72	37.2	2.5	62	33.6	1.5	198	37.7	2.1
14	14	43.3	1.5	16	39.5	2.7	22	42.8	1.8

Wujiawa village is one of the areas in our city with a high rate of dental fluorosis in children. High fluoride seriously effects the growth and mental development of these children. After using low fluoride water for eight years, obvious prevention effects have been achieved. In our investigation, although the overall IQ level is currently lower than the non-fluorosis area, it is obviously higher than the fluorosis area without water improvement. Moreover, the average IQ among the children born after the implementation of the water improvement program was not obviously different from that of the same aged children from the non-fluorosis area. Likewise, each of the morphological indices among this group of children has basically reached the development of normal children from the non-fluorosis area. This indicates that water improvement and defluoridation are very effective in improving the mental and physical development of children from a fluorosis area.

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Table 4: Comparison of sitting height of children in different age groups in endemic fluorosis area with and without water improvement (cm)

Age (years old)	Fluorosis Area with Water Improvement			Fluorosis Area without Water Improvement			Non-Fluorosis Area		
	No. of children	Mean	Standard Deviation	No. of children	Mean	Standard Deviation	No. of children	Mean	Standard Deviation
8	144	66.9	2.4	64	65.1	2.3	168	67.0	2.7
10	138	70.5	3.0	46	70.2	2.9	166	71.0	2.1
12	72	76.9	3.2	62	75.0	2.6	198	77.2	2.9
14	14	83.7	2.5	16	79.1	2.1	22	84.2	2.3