

Full Length Research Paper

Intelligence quotient of 7 to 9 year-old children from an area with high fluoride in drinking water

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This paper reports the effect of chronic high fluoride exposure on children's intelligence quotient (IQ). In this cross sectional study, two urban communities with similar socio-economic and cultural status but with different levels of fluoride in drinking water, in Kerman province of Iran were studied: Koohbanan City (fluoride 2.38 mg/L), Baft City (fluoride 0.41 mg/L). Study samples consisted of 119 children 6 to 9 years old: 59 children from Koohbanan and 60 children from Baft. Raven's progressive matrices used to determine the effect of fluoride exposures on children's IQ. The statistical analysis was carried out using the t-test, the chi-square test and the Mann-Whitney test. In the low fluoride area (control group), the mean IQ score of children was 97.80 ± 15.95 that decreased to 91.37 ± 15.63 for the high fluoride group (Koohbanan's children), it was significantly different from the control group ($P < 0.05$). Although fluoride is widely promoted for prevention of dental caries, its overconsumption may lead to dental fluorosis and other adverse effects. Based on the findings, the chronic exposure to high levels of fluoride can be one of the factors that influence intellectual development. Therefore, it is necessary to think about some solutions for preventing the bad effects of excessive intake of fluoride ion to the body, especially in cities like Koohbanan.

Key words: Fluoride, fluorosis, intelligence quotient, Raven test.

INTRODUCTION

Excessive fluoride intake by different tissues of human body can lead to some deficiencies (Shashi, 2003; Tang et al., 2008). However, there are relatively few reports about the effects on children intellectual ability. So, we studied the intelligence quotient (IQ) of 7 to 9 year-old children born and resident in Koohbanan, a city located 160 km north of Kerman, the capital of Kerman Province in Iran, is situated in a cold mountainous region 2200 m above sea level. The highest part of Koohbanan is the mountain top at 3660 m. Most mountains and hills around the city have coal mines. In this region, some of vegetables and fruits are grown by the inhabitants, and drinking water and agricultural water are provided from separated sources. Recently in our study, the fluoride level in various foods in Koohbanan was found to be

between 0.02 to 8.85 ppm and in drinking water 2.38 ppm; in the vegetables, the fluoride concentrations were more than 3 ppm (Poureslami et al., 2008). In addition, the prevalence of dental fluorosis among 12 to 14 years old secondary school students of this city was reported to be 93% with a mean intensity of grade III, based on tooth surface index of dental fluorosis (TSIDF) (unpublished findings). In another research, we have found the average amount of fluoride ion 24-h urine of 4 to 5 year-old children with a mean body mass of 16 kg in Koohbanan was 0.41 mg, and the total 24-h fluoride intake was 1.71 mg. A daily consumption of 1.71 mg fluoride corresponds to a dosage of 0.107 mg fluoride/kg bw/day (Poureslami and Khazaeli, 2010). This dosage is twice the widely cited maximum of 0.05 mg fluoride/kg bw/day for the prevention of dental fluorosis (Garrow et al., 2000). In comparing the fluoride intake and fluoride excretion, only 24% of the fluoride intake was excreted in the urine. This relatively low level of fluoride excretion

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Table 1. Comparison of the IQ ranks of the Baft and the Koohbanan children.

IQ rank	Percent of Baft children (No.)	Percent of Koohbanan children (No.)	Total percent (No.)
Borderline	20 (12)	27.12(16)	23.53 (28)
Below average	20 (12)	28.81 (17)	24.37 (29)
Average	30 (18)	25.42(15)	27.73 (33)
Above average	13.33 (8)	5.08(3)	9.24 (11)
Excellent	16.66 (10)	13.56 (8)	15.13 (18)
Total	100 (60)	100 (59)	100 (119)

Table 2. Comparison of the IQ levels of the boys and the girls.

City	Boys (No.)	Girls (No.)	P
Koohbanan	90.28±15.97(29)	92.43±15.48(30)	>0.05
Baft	99.89±14.40(28)	95.97±17.21(32)	>0.05

may be due to the high altitude of Koohbanan. According to some studies, living at high altitudes causes hypoxia leading to greater fluoride accumulation in body tissues (Rwenyonyi et al., 1999; Cao et al., 2001). These findings indicated that the fluoride intake and fluoride accumulation in body tissues in Koohbanan preschool children is high.

In continuation of these studies, we decided to investigate the effect of chronic high fluoride exposure on Koohbanan children intelligence. These children suffered from dental fluorosis that has not been observed in similar studies.

MATERIALS AND METHODS

In this cross sectional study, 60 students, 7 to 9 year-old (20 students in each age group) were selected. Exclusive criteria were included: Genetic, congenital or acquired diseases related to nervous systems in past or present. Inclusive criteria included signs of dental fluorosis grade III or more (according to TSIDF index) on the labial surface of their maxillary permanent central incisors. IQ was determined by one researcher via standard Raven's Progressive Matrices which is specific to this age group. Validity and reliability of the test are approved via some studies in Iran (Rahmani and Abedi, 2004; Sharifi, 2008). Besides, 60 students with the similar physical and mental health, born and resident in Baft city were examined as the control group. These students were 7 to 9 year-old and they lacked any sign of fluorosis on the labial surface of their permanent central incisors. Baft is a city in the kerman province which is 280 Km far from Koohbanan. It is 2300 m above sea level, and its climate, socioeconomic and cultural status and educational facilities are similar to Koohbanan. Their only difference is the amount of fluoride in their drinking water 0.41 mg/L in Baft, (Poureslami et al., 2008).

Raven's progressive matrices are multiple choice intelligence tests of abstract reasoning, originally developed in 1936. The booklet comprises five sets (A to E) of 12 items each (e.g., A1 through A12), with items within a set becoming increasingly difficult, requiring ever greater cognitive capacity to encode and analyze information. The Raven's test was designed to minimize the biases

that language difference can create to measure your intelligence. The scores from children's intelligence tests were measured by the Raven's test, that psychometric properties of its Persian version was assessed (Rahmani and Abedi, 2004; Sharifi, 2008). This version has been used for IQ tests for Iranian children. Their intellectual ability ranking was as follows: IQ = 70 to 79 borderlines, IQ = 80 to 89 below average, IQ = 90 to 109 average, IQ = 110 to 119 above average, IQ = 120 to 129 excellent and IQ > 129 superior. Data were analyzed by SPSS software; t test and Mann-Whitney test were used when appropriate. The finding presented as means and standard deviation. P<0.05 was considered as statistically significant.

RESULTS

After carrying out the Rayon test, for the students of the two cities, the answer sheets were evaluated and scored with the standard method. Only one of the answer sheets which belonged to a student of Koohbanan was not evaluated because it was incomplete. Finally, the IQ of each group registered according to the chronologic age.

The average of Baft students' age was 8.1 and Koohbanan students' was 7.9 year old. There was not significant statistical difference between the students of the two cities (P = 0.152).

The IQ of 30% of Baft students and 25.4% of Koohbanan students was in the range of average. IQ of none of the students of the two cities was ranked as > 129 (Table 1).

The average of the IQ of Baft students was 97.80±15.95 and this average was 91.37±15.63 for Koohbanan students, in the both cities there was not any significant difference between the IQ of boys and girls (Table 2). In each of the triple groups (7.8 and 9 years old), IQ level of Baft students were higher than Koohbanan students. There was significant difference between of IQ of Baft students and Koohbanan students (Table 3).

Table 3. Comparison of the IQ levels of the Koohbanan and the Baft children.

City	Number of children	IQ level	P
Koohbanan	59	91.37±15.63	<0.05
Baft	60	97.80±15.95	

DISCUSSION

According to the results, the IQ of Baft students was significantly higher than Koohbanan students ($P = 0.028$), this result confirms the results of the other studies (Amador et al., 2007; Chen et al., 2008; Guo et al., 2008; Liu et al., 2008).

There was not a significant relationship between IQ and gender. This fact was also proved in the studies of Zhao and Seraj (1996, 2006). In Xian et al. (2003) study in one village there was a significant relationship between IQ and gender and in another village there was not. In psychological books, also gender is mentioned as a non related factor to IQ (Beirne-Smith et al., 2005).

This study showed that the percentage of the students ranked in the ranges of average, above average and excellent were higher in Baft than the students in the same ranks in Koohbanan. The percentage of the students ranked in the ranges of below average and borderline were higher in Koohbanan than in Baft. These findings support the idea of the influence of high fluoride on the intellectual ability. Koohbanan children live next to the Coal Mountains at the high altitude, it seems that living in the high altitudes causes tissues hypoxia and leads to accumulation of fluoride in their tissues (Rwenyonyi et al., 1999; Cao et al., 2001). In addition, living next to the Coal Mountains causes the entrance of fluoride ion to the body through the air (Guo et al., 2008) and these increases the harmful effects of fluoride. It seems in areas with high fluoride in drinking water, the amount of arsenic in drinking water to be also high. The studies have shown that children intelligence can be affected by high concentrations of arsenic (Amador et al., 2007; Wang et al., 2007). So, in Koohbanan City, where perhaps arsenic is high in drinking water and low in IQ scores of Koohbanan children, it may be due to the high level of arsenic in drinking water. It is necessary to determine the amount of arsenic in drinking water in Koohbanan.

Conclusion

Although fluoride is widely promoted for prevention of dental caries, its overconsumption may lead to dental fluorosis and other adverse effects. Based on the findings, the chronic exposure to high levels of fluoride can be one of the factors that influence intellectual development.

Therefore, it is necessary to think about some solutions for preventing the bad effects of excessive intake of fluoride ion to the body, especially in cities like Koohbanan.

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REFERENCES

- Amador DR, Navarro ME, Carrizales L, Morales R, Calderon J (2007). Decreased intelligence in children and exposure to fluoride and arsenic in drinking water. *Cad Saude Publica Rio de Janeiro*, 23: 5579-5587.
- Beirne-Smith M, Patton JM, Kim SH (2005). *Mental Retardation: An Introduction to Intellectual Disability*. 7th edn.
- Cao J, Zhao Y, Liu J, Xirao R, Danzeng S (2001). Varied ecological environment and fluorosis in Tibetan children in the nature reserve of Mount Qomolangma. *Ecotoxicol. Environ. Saf.*, 48(1): 62-65.
- Chen Y, Han F, Zhou Z, Zhang H, Jiao X, Zhang S, Huang M, Chang T, Dong Y (2008). Research on the intellectual development of children in high fluoride areas. *Fluoride*, 41(2): 120-124.
- Garrow JS, James WPT, Ralph A (2000). *Human nutrition and dietetics*. 10th ed. London: Churchill Livingstone.
- Guo X, Wang R, Cheng C, Wei W, Tang L, Wang Q, Tang D, Liu G, He G, Li S (2008). A preliminary investigation of the IQs of 7-13 year old children from an area with coal burning-related fluoride poisoning. *Fluoride*, 41(2): 125-128.
- Liu S, Lu Y, Sun Z, Wu L, Lu W, Wang X, Yan S (2008). Report on the intellectual ability of children living in high fluoride water areas. *Fluoride*, 41(2): 144-147.
- Poureslami HR, Khazaeli P, Noori GR (2008). Fluoride in food and water consumed in Koohbanan, Iran. *Fluoride*, 41(3): 216-219.
- Poureslami HR, Khazaeli P (2010). Fluoride intake and urinary excretion in preschool children residing in Koohbanan, Iran - A city with high fluoride water and food. *Fluoride*, 43(1): 67-70.
- Poureslami HR, Khazaeli P, Masoodpour H (2008). Fluoride content of drinking waters in Kerman province/ Iran. *J. Kerman Univ. Med. Sci.*, 15(3): 235-242.
- Rahmani J, Abedi MR (2004). Standardization of test color Rayon children 5-10 years in Isfahan-Iran. *J. Educ. Res.*, 23: 81-86.
- Rwenyonyi C, Bjorvaten K, Birkeland J, Haugejorden O (1999). Altitude as a risk indicator of dental fluorosis in children residing in areas with 0.5 and 2.5 mg fluoride per liter in drinking water. *Caries Res.*, 33(4): 267-274.
- Seraj B, Shahrabi M, Fallahzadeh M, Fallahzadeh F, Akhondi N (2006). Effect of high fluoride concentration in drinking water on children's intelligence. *J. Dent. Tehran Univ. Med. Sci.*, 19(2): 80-82.
- Sharifi PH (2008). *Principles of psychometrics and mental trial*. Roshd Iran Ed. (ISBN 964-6115-37-3), pp. 44-53.
- Shashi A (2003). Histological investigation of fluoride induced neurotoxicity in rabbits. *Fluoride*, 36: 95-105.

Tang QQ, Du J, Ma HH, Jiang SJ, Zhou XJ (2008). Fluoride and children's intelligence: A Meta-analysis. *Biol. Trace Elem. Res.*, 126(1-3): 115-120.

Wang S, Wang Z, Cheng X, Li J, Sang Z (2007). Arsenic and fluoride exposure in drinking water: Children's IQ and growth in Shanyin County, Shanxi province, China. *Environ. Health Perspect.*, 115(4): 643-647.

Xiang Q, Liang Y, Chen L (2003). Effect of fluoride in drinking water on children's intelligence. *Fluoride*, pp. 84-94.

Zhao LB, Liang GH, Zhang DN (1996). Effect of a high fluoride water supply on children intelligence. *Fluoride*, 29: 190-192.