A COMPARATIVE STUDY OF THE IQ OF CHILDREN AGE 7–9 IN A HIGH AND A LOW FLUORIDE WATER CITY IN IRAN

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SUMMARY: A study was conducted to evaluate the effect of high and low fluoride (F) in the drinking water on the Intelligence Quotient (IQ) of young schoolchildren in two otherwise similar high-altitude communities in a mountainous region of Kerman Province, Iran. The study sample consisted of 120 boys and girls age 7–9: 60 in the city of Koohbanan (pop. 12,253; elev. 2200 m) with 2.38 ppm F in the water and 60 in the city of Baft (pop. 14,628; elev. 2300 m) with 0.41 ppm F in the water. Using a Persian version of Raven's Progressive Matrices Intelligence Test, the mean IQ scores of the children in low F Baft was 97.80±15.95, and in high F Koohbanan it was significantly lower at 91.37±15.63 (p = 0.028).

Key Words: Baft, Iran; Children's IQ; Dental fluorosis; Fluoride in food; Fluoride intake; Iran; Intelligence quotient (IQ); Kerman Province, Iran; Koohbanan, Iran.

INTRODUCTION

Besides dental and skeletal fluorosis, excessive fluoride (F) intake can also affect the central nervous system without first causing the physical deformities associated with skeletal fluorosis. Thus, as an extreme example, toxic neuronal injury in the form of tetaniform convulsions in a 12-year-old boy from ingestion of 1-ppm fluoridated drinking water was described in detail and found to subside with nonfluoridated water.[1] Over the last two decades more subtle injury from F in the form of lower intelligence has been reported in China,[2-7] India[8,9] and Iran.[10] In the present study, the effect of a high and a low fluoride drinking water on the Intelligence Quotient (IQ) of young school children in two otherwise similar mountainous communities of Kerman Province in SE Iran, has been investigated.

The high F (2.38 ppm) water city chosen for this study was Koohbanan,[11] population 12,253 in 2007, located 160 km north of the provincial capital Kerman at an elevation 2200 m above sea level with a mean annual temperature of 14.5ºC. The low F (0.41 ppm) water city was Baft,[12] population 14,628 in 2007, located 280 km southwest of Koohbanan at an elevation 2300 m above sea level with a mean annual temperature of 14.0ºC. In addition to these features, the two cities have a similar socioeconomic and cultural status and educational facilities. The number of children age 7–9 born and living in Koohbanan was recorded in 2007 as 595 and in Baft it was 621. As expected, the prevalence of dental fluorosis in Koohbanan is quite high but is comparatively low in Baft. In a recent study[11] we found the total 24-hr F intake among 4–5 year old preschool children in Koohbanan to be 1.71 mg.

MATERIALS AND METHODS

Initially, the aims of the study were explained verbally to each parent and child, and an information sheet was also given to them. Before the test, they gave their written consent according to Ethical code K/88/48.

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Similar to the size of a recent IQ study in China,[6] the cluster randomized sample was 120 students 7–9 years old with 60 students selected from different schools in each of the high and low fluoride cities (Table1).

Exclusion criteria included genetic, congenital, or acquired diseases related to the nervous system, past or present. For the 60 students in Koohbanan, with 2.38 ppm F in the drinking water,[11] inclusive criteria included signs of grade III TSIDF (total surface index of dental fluorosis) or more, i.e., visible fluorosis on least two thirds of the labial surface of the maxillary permanent central incisors. In each case the examiner was one of the investigators. For the 60 students in the control city of Baft with 0.41 ppm F in the drinking water,[12] similar physical (same range of weight, height) and mental health (usual school, no history of mental disorders) criteria were adopted. However, these children lacked any sign of fluorosis on the labial surface of their permanent central incisors.

The Raven's Progressive Matrices Intelligence Test used in this study consists of a series of multiple choice tests (in Persian) 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 four first questions were explained to the child, and when the child understood how to answer, he or she was told to answer the remaining questions. The test was administered by a teacher who had been trained by a psychologist, and the Raven's scoring was calculated on the basis of the Persian version of the test.[13]

Intellectual ability ranking was as follows: IQ = 70–79 borderline, IQ = 80–89 below average, IQ = 90–109 average, IQ = 110–119 above average, IQ = 120–129 excellent, and IQ >129 superior. After the Raven's tests were completed in the two cities, the answer sheets were collected, tabulated, and evaluated. The data were then analyzed by SPSS v.13.0 software. Where appropriate, t test and Mann-Whitney test were used. Results are means and standard deviation. $P < 0.05$ was considered statistically significant.

RESULTS

After the tests in the two cities were completed, the answer sheets were scored and the results tabulated as shown in Tables 1–3.

Table 1. Baseline characteristics of the study children and water F in Baft and Koohbanan

City in Kernan Province	No. of girls (%)	No. of boys (%)	Total (%)	F in drinking water (mg/L)
Baft	32 (51.61)	28 (48.28)	60 (50)	0.41
Koohbanan	30 (48.39)	30 (51.72)	60 (50)	2.38
Total	62 (100)	58 (100)	120 (100)	

Table 2. Comparison of the IQ rankings the 7–9 year-old children in Baft and Koohbanan

IQ rank	No. of Baft children (%)	No. of Koohbanan children (%)	Total Number (%)
Borderline	12 (20)	16 (27.12)	28 (23.53)
Below average	12 (20)	17 (28.81)	29 (24.37)
Average	18 (30)	15 (25.42)	33 (27.73)
Above average	8 (13.33)	3 (5.08)	11 (9.24)
Excellent	10 (16.67)	8 (13.56)	18 (15.13)
Total	60 (100)	59 (100)	119 (100)

Table 3. Comparison of children's IQ by gender and city (values are mean± SD)

Gender	Number	Baft	Koohbanan
Girls	62	95.97±17.21	92.43±15.48*
Boys	57	99.98±14.40	90.28±15.97†
Total	119	97.80±15.95	91.37±16.63†

*p>0.05 (NS); †p<0.05 (significant compared with the Baft scores).

One answer sheet from a Koohbanan was incomplete and therefore there are only 59 scores for that city.IQ scores in the range of average (90–109) occurred for 30.0% (18/60) of the students in low F Baft and 25.4% (15/59) of the students in high F Koohbanan. None of the students in either city had a superior IQ >129 (Table 2). The average IQ score of the 60 Baft students was 97.80±15.95, and the average IQ score of the 59 Koohbanan students was 91.37±15.63. This difference is statistically significant ($p = 0.028$). There was also a significant difference between the IQ of the boys in Baft and the boys in Koohbanan (Table 3). However, the IQ difference between the Baft and Koohbanan girls was not significant.

DISCUSSION

The significantly higher mean IQ of the students in low F water Baft than in high F water Koohbanan agrees with findings of other F/IQ studies.[2-10] Thus, Liu et al., in comparing the lower IQ scores of 60 children age 10–12 in a high F water (3.15 mg/L) area with those of 58 control children of the same age in a nearby low F water (0.37 mg/L) area found "there were significantly more borderline and low IQs in the high F area (13/60) than in the low F area (2/58) ($p<0.01$)."[6] Similarly, in an earlier larger study, Chen et al. observed a significantly lower average IQ of 320 children age 7–14 in an area with 4.55 mg F/L in the drinking water compared to the IQ of 320 children of the same age born and residing in an area with 0.89 mg F/L in the drinking water ($p<0.01$).[2] In another early investigation, Guo et al. compared the IQs of 7–13 year-old children living in areas with and without endemic dental fluorosis and found a significantly lower IQ in the 7–9 year-old children in the endemic fluorosis area,[3] just as we have found in the current study. The standardized Raven's IQ test was used in the Liu and Chen studies, but in the

Guo study the Chinese Binet IQ test was used. In our study, in agreement these studies, the percentage of students ranked in the ranges of average, above average and excellent were higher in low F Baft than the percentage of students in the same ranks in high F Koohbanan. Likewise, the percentage of the students ranked in the ranges of below average and borderline were higher in Koohbanan than in Baft.

Our findings therefore support the view that exposure to elevated F can cause lower IQ. Koohbanan children living at high altitude as well as near mountain coal mining operations may have increased susceptibility to tissue hypoxia from excessive accumulation and harmful effects of F in those tissues.[3,14,15] Our findings also revealed a significant difference between the IQ of the Baft and Koohbanan boys, but this difference was not significant between the IQ of the girls. Although the Chen and Guo groups in their studies[2,3] did not make comparisons between IQ scores of boys and girls, their data indicate that the IQ difference between the girls was smaller than between boys in the same areas.

From all that has been reported, it is now clear that excessive intake of F can produce harmful effects on the developing brain,[16] the detailed mechanism by which F influences IQ is not known, and more studies in this area are needed. On the other hand, appropriate measures to remove F from the drinking water in Koohbanan is strongly recommended. There are also studies showing that children's IQ can also be affected by high waterborne concentrations of arsenic,[17,18] but we have not found any report about the amount of arsenic in the Koohbanan drinking water, nor have we been able to measure it. It should also be noted that there are other confounding variables including genetic, nutritional, and other toxic environmental factors such as lead that can potentially influence IQ. In addition, measurement errors due to limitations of IQ tests need to be considered.

Based on our findings, chronic exposure to high levels of F definitely appears to be one of the factors that can decrease the IQ of children.

ACKNOWLEDGEMENT

Financial support provided by the Vice Chancellor for Research, Kerman University of Medical Sciences, is warmly acknowledged.

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