Decreased Magnesium in the Hair of Autistic Children

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Abstract

Concentrations of 16 nutrient minerals ar seven toxic minerals were determined in scalp hair samples from a group of 28 autistic children and 18 controls. Autistic children had significantly lower amounts of magnesium and calcium in their hair than did controls. On the basis of a stepwise discriminant function of the 23 minerals, 85 percent of the autistic children were correctly classified with magnesium levels accounting for 18 percent of the variance between the two groups. Possible relationships between magnesium deficiency and early childhood autism are discussed.

Introduction

The etiology of early childhood autism is largely unknown. Abnormal mineral metabolism can cause a variety of illnesses (Rimland, 1973), and scalp hair has been proposed as a convenient sampling tissue for evaluating an individual's burden of certain minerals (Bland, 1979; Laker, 1982). The first purpose of this research was to determine if concentrations of certain minerals in the hair of autistic children were different from their non-autistic siblings. The second purpose was to determine the relative importance of each mineral to the discrimination of the two groups.

Method Subjects

Parent members of the National Society for Autistic Children in Colorado and Montana were contacted and asked to submit hair samples from their autistic child and a non-autistic sibling for trace mineral analysis. Parents without a non-autistic child were asked to submit a hair sample from a same-sex, same-age child in their neighborhood. Twenty-eight parents consented, resulting in a subject population of 28 autistic children and 18 controls (14 siblings, four neighborhood children). All of the autistic children were classified as autistic using the definition of the National Society for Autistic Children (Ritvo and Freeman, 1977). The mean age of the autistic children was 8.85 ± 4.06, and the mean age of the controls was 10.83 ± 4.55 (p = NS). There were 24 males in the autistic group compared to 10 males in the control group ($p < .05$). All 46 subjects were Caucasian and from middle class urban families. Of the 28 autistic children, 19 were reported to be on psychotropic medicines. Medications included phenothiazines, butyrophenones, anti-Parkinson drugs and antiepileptic drugs.

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Classification of Hair Mineral Levels

Every part of the human body contains at least a few atoms of every stable element in the periodic table. Although a large number of these elements are found in detectable amounts in human tissue, blood and urine, hair, in particular, contains a higher concentration of many of these elements. Trace elements are accumulated in hair at concentrations that are generally higher than those present in blood serum, provide a continuous record of nutrient-mineral status and exposure to toxic minerals, and may serve as a probe of physiologic functions (Laker, 1982; Maugh, 1978). Scalp hair has several characteristics of an ideal tissue for epidemiologic study in that it is painlessly removed, normally discarded, easily collected, and its contents can be analyzed relatively easily.

Parents received verbal and written instructions on the hair collection procedure. Hair samples (about 400 mg) were collected from the nape of the children's neck, as close to the scalp as possible. The hair samples were then submitted to Doctor's Data, Inc., a state and Center for Disease Control licensed laboratory in West Chicago, where they were analyzed with three instruments (the atomic absorption spectrophotometer, Hydride Analysis, and the induction coupled plasma torch) to determine seven toxic mineral levels and 16 nutrient mineral levels. The seven toxic mineral levels tested for were lead, arsenic, mercury, cadmium, aluminum, nickel, and beryllium. The 16 nutrient mineral levels tested for were calcium, magnesium, sodium, potassium, copper, zinc, iron, manganese, chromium, phosphorous, selenium, molybdenum, silicon, lithium, cobalt, and vanadium.

Precise laboratory techniques were used to assure the reliability of results and to meet reproducibility requirements including:

1. A blind sample was run from the initial steps through the entire procedure to assure reproducibility of methods;
2. At least one of every three tests was a standard. Working standards were made to assure proper values;
3. The in-house pool was completely remade and analyzed monthly to eliminate the possibility of precipitating elements and to assure reproducibility;
4. Temperature and humidity were controlled to assure reliability and consistency of the testing instruments;
5. The hair samples were weighed to the thousandths of a gram (.001g is equal to approximately four hairs), 1 inch (.0254 m long); and only volumetric flasks, the most accurate available, were used for diluting the ashed sample;
6. Lot-number control sheets for all reagents were used to assure uniformity and records were kept and available for inspection;
7. All glassware was acid washed in-house before use and between each use, including acid prewashed disposable test tubes;
8. The water used was virtually mineral free, rated at 18+ MEG; and
9. Upon receipt, the hair sample was washed thoroughly with deionized water, a non-ionic detergent, and an organic solvent to remove topical contaminants.

Reports summarizing the significant findings of the hair analysis for each subject were received from Doctor's Data, Inc., subsequent to analysis. A report summarizing the laboratory findings of Doctor's Data, Inc., consisted of two main sections. The first section summarized the significant findings related to the 16 nutrient-mineral levels. These findings were based on a statistical comparison of the levels determined in the present analysis with those observed in a normal population. The second section dealt with the seven toxic minerals. If the mineral analysis indicated any of these elements to be above generally accepted upper limits, the name of this element was printed on the report and supplemental information was enclosed with the report. In addition, this section of the report listed both the observed hair level and the suggested upper limit for each toxic mineral and plotted each level in relation to the upper limit.

Results

The two groups of children were compared for hair mineral concentrations. As shown in Table 1, the mean hair concentrations of magnesium and calcium were considerably below those of the control children, while the autistic group's mean hair phosphorous level

 Table 1 Results of Trace Mineral Analysis Mean ± S.D.

Trace Mineral	Autistic Group (ppm)		Control Group (ppm)		Normal Range[a] (ppm)
Lead	6.28 ±	2.12	6.66 ±	2.49	15.00[b]
Arsenic	3.55 ±	1.13	3.87 ±	0.69	7.00[b]
Mercury	0.88 ±	0.37	0.96 ±	0.49	2.50[b]
Cadmium	0.60 ±	0.62	0.51 ±	.0.28	1.00[b]
Aluminum	11.03 ±	8.12	13.00 ±	7.75	30.00[b]
Nickel	1.25 ±	0.62	1.54 ±	1.18	2.20[b]
Beryllium	0.03 ±	0.02	0.03 ±	0.01	0.10[b]
Calcium	230.82 ±	216.60**	958.83 ±	1253.69	343.00 - 780.00
Magnesium	20.64 ±	12.04**	67.11 ±	79.49	36.00 -142.00
Sodium	50.92 ±	63.07	48.44 ±	68.53	19.00 -123.00
Potassium	26.32 ±	26.09	20.77 ±	34.51	10.00- 84.00
Copper	15.00 ±	15.76	26.00 ±	31.97	13.00- 63.00
Zinc	131.35 ±	31.10	140.38 ±	28.38	123.00 -172.00
Iron	14.92 ±	9.98	13.66 ±	7.23	7.68- 23.00
Manganese	0.33 ±	0.26	0.50 ±	0.41	0.33 - 1.96
Chromium	0.78 ±	0.23	0.87 ±	0.28	0.63 - 1.10
Phosphorus	134.82 ±	27.17*	116.50 ±	27.61	102.00 -178.00
Selenium	0.26 ±	0.34	0.11 ±	0.14	0.16 - 0.88
Molybdenum	1.24 ±	0.87	1.48 ±	0.81	0.25 - 1.65
Lithium	0.03 ±	0.03	0.04 ±	0.04	0.01 - 0.45
Silicon	14.21 ±	21.27	7.77 ±	1.16	5.14- 10.00
Cobalt	0.23 ±	0.05	0.28 ±	0.15	0.13 - 0.35
Vanadium	0.17 ±	0.08	0.19 ±	0.12	0.16 - 0.21

[a]Theoretical Normal Range (±1 SD) established by Doctor's Data, Inc. (1983). [b]Normally tolerated limited established by Doctor's Data, Inc. (1983). *p < .01 by two tailed t-test. **p < .05 by two tailed t-test.

was considerably above that of the controls. The data were analyzed with the t-test for two independent samples design of SPSS (Nie et al., 1975), yielding significant t values for magnesium (t = -3.06, 44, p < .01), calcium (t = -3.02, 44, p < .01) and phosphorous (t = -2.22, 44, p < .05). The results of the t-tests on the other nutrient and toxic elements were nonsignificant.

As also shown in Table 1, the autistic group's mean hair magnesium and calcium levels were below the theoretical normal range (±1 SD) established by Doctor's Data, Inc. (1983). The autistic group evidenced mean hair magnesium and calcium levels of 20.64 ± 12.04 and 230.82 ± 216.60 parts per million (ppm) compared to the normal ranges of 36-142 ppm and 343-780 ppm, respectively.

The autistic group's mean hair phosphorous level was within the normal range. The autistic group's mean hair silicon level was above the normal range, but this was due to a large standard deviation with two autistic children evidencing extremely high hair silicon levels.

A discriminant analysis was then performed using a program from SPSS (Nie and Hull, 1979). The stepwise method using Wilks Lambda was employed to ascertain the relative contributions of the 23 minerals to the separation of groups.

The combination of magnesium and selenium in order of entry into the discriminant function significantly separated the autistic and control children ($F2, 44 = 6.54$, $p < .01$). Both magnesium and selenium contributed uniquely over and above the previously entered minerals to the discrimination between groups ($F = 9.31$, 3.26, respectively). The standardized canonical discriminant function coefficients revealed that magnesium (.87) was more important than selenium (-.55) to the discrimination between groups.

Stepwise discriminant analysis revealed that magnesium accounted for 18 percent of the variance of the two groups, and selenium accounted for an additional six percent. Overall, the two minerals accounted for about 24 percent of the variance of the two groups. On the basis of the discriminant function 85.7 percent of the autistic children and 50 percent of the control children were correctly classified. These percentages are optimistic however, since the function was applied to the data that produced it. A cross validation of the discriminant function is expected to result in somewhat smaller percentages.

Discussion

The value of the above study is that it presents the baseline concentrations of some nutrient and toxic minerals in the hair of autistic children. The literature on the subject contains a lack of data for direct comparison.

The most noteworthy outcome of the present study was the decreased levels of hair magnesium in the autistic children in comparison to controls and laboratory norms. There are a variety of possible theories regarding magnesium's relationship to early childhood autism.

First, magnesium is essential to the body's utilization of vitamin B6, and numerous recent studies have demonstrated that autistic children showed marked improvement when given a large daily supplement of vitamin B6 and magnesium (Rimland, Calloway, and Dreyfus, 1978; Lelord et al., 1981; Martineau et al., 1981). B6 is a ubiquitous coenzyme, and plays a role in the metabolism of numerous transmitters (Ebadi, 1972). A variety of genetic CNS diseases are responsive to pharmacological doses of B6 (Rosenberg, 1974), and B6 deficiency has been noted in some autistic children (Rimland, 1973). From a therapeutic point of view B6 is active in catecholamine decarboxylation (Swanson and Stahl, 1976). It is therefore possible that the therapeutic effects of B6 and magnesium are connected, at least in part, to modifications in the metabolism of dopamine. If dopaminergic systems are immature or abnormal in autism (DeMasio and Maurer, 1978), this could explain the effects of B6 and magnesium on autistic children. Magnesium's essential role in the utilization of B6 is also seen in Rimland's (1974) observation that some autistic children experienced increased irritability, sound sensitivity, and enuresis when B6 was given in large amounts, but these problems promptly disappeared when increased amounts of magnesium were added to these children's dietary intake.

A second hypothesis is that magnesium deficiency in itself influences neurotransmitter metabolism (Alexander, van Kammen and Bunney, 1979). Symptoms of magnesium deficiency include confusional states, increased neuromuscular irritability, hyper-reflexia, and multifocal and generalized seizures (Fishman, 1965). In an even more speculative vein, Laskay (Note 1) reports positive responses in autistic children treated with lithium, and Pavlinac, Langer, Lenhard and Deftos (1979) found that the administration of lithium resulted in increased serum magnesium, and suggested that the effects of lithium on mania may be mediated via change in magnesium.

A third hypothesis concerning hair magnesium deficiency relates to the fact that eight of the autistic children were reported to be on antipsychotic drugs. Alexander, van Kammen and Bunney (1979) reported a significant decrease in both magnesium and calcium serum levels in patients during the administration of pimozide, an antipsychotic drug. Importantly, as magnesium and calcium serum levels decreased, extrapyramidal symptoms induced by neuroleptic treatment increased.

The significantly increased hair phosphorous levels in the autistic group and hair selenium's contribution to the separation of the groups may represent nutritional peculiarities of the sample population. The autistic group's hair phosphorous and hair selenium levels were both within the range of laboratory norms.

There were no significant differences in the seven toxic minerals of the two groups. Levels of lead in the hair have been correlated to the presence of lead in the blood (Chattopadhyay, Roberts and Jervis, 1977) and two previous reports indicated elevated blood lead in autistic children (Campbell et al., 1980; Cohen, Johnson and Caparulo, 1976). None of the autistic children evidenced elevated hair lead levels, and their average level was considerably below previously reported mean hair lead levels of 10.78 ppm for emotionally disturbed children (Marlowe et al., 1983), 14.10 ppm for mentally retarded children (Marlowe et al., 1983) and 11.38 ppm for learning disabled children (Marlowe et al., in press).

In summary, this study simply indicates that decreased hair magnesium levels contributed significantly to the separation of autistic children from controls. On the basis of the discriminant function 23 of the 28 autistic children were correctly classified. There are a variety of possible theories as to why this occurred. We simply present this evidence to encourage others to examine hair minerals' relationship to early childhood autism.

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