

Mineral Deficiencies and Developmental Delays in Children

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Hair Metals Test Analysis has been used to assess sufficiency of Iodine, Selenium and Molybdenum in children with autism. Iodine deficiency was found to be very common, as well as Selenium deficiency and Molybdenum deficiency. All children tested had a deficiency in at least one of the metals. Each of Iodine, Selenium and Molybdenum is an essential cofactor in the activation of vitamin B2, and hence potentially each child was also deficient in functional vitamin B2. Functional vitamin B2 is an essential co-factor in the activity of vitamin B12, and potentially this would also mean that each child was deficient in functional vitamin B12 – a known predisposing factor for developmental delay.

Keywords

Autism, Minerals, Iodine, Selenium, Molybdenum.

Introduction

Iodine deficiency has been recognized by the WHO as the single most preventable cause of mental retardation in the world and has mandated Iodine supplementation in all countries. It has been known for many years that Iodine deficiency in pregnancy impairs the neurological development of the fetus, and as such Iodine deficiency in the mother can cause irreversible brain damage to the fetus resulting in severe mental retardation" [1-10]. Thus, Iodine deficiency in the neonate is associated with mental retardation, increased perinatal mortality, retarded physical development, and reduced verbal IQ [11].

Despite this, insufficient iodine intake in mothers is common in many countries including the USA [12], Canada, UK (73% deficient, [13], Spain [14], Australia, and New Zealand (40% deficient, [15,16]. Iodine deficiency is more common in families that do not use Iodized salt, who have low dairy intake, or consume "gluten-free" products. Plant-based diets are low in Iodine, and as such vegans may be at risk of Iodine deficiency [17,18]. The incidence of "gluten-free" consumption now is very common with as much as 25% of persons in the US, UK, and Australia adopting a nutrient poor, gluten-free diet.

Iodine deficiency and its effects have been known for over 100 years, and Iodine supplementation was introduced into the USA in 1924, however, Iodine levels have been dropping in the US since 1971, and levels of Iodine intake halved in the period 1971 to 1994. The situation has steadily become worse, and over 50% of women admitted into Boston Maternity wards in 2008 were found to have insufficient Iodine intake [12], with 23% being deficient in Iodine in Michigan, USA [19,20]. Similarly, in a recent study in Australia, over 40% of women of child-bearing age were found to have insufficient Iodine intake [16]. Iodine intake tended to be lower in women on vegan diets.

Selenium is an essential cofactor in 25 selenoproteins in the body, including glutathione peroxidase, thiodoxin reductase and three different selenium-dependent iodothyronine deiodinases (types I, II, and III) that can both activate and inactivate thyroid hormones, making selenium an essential micronutrient for normal development, growth, and metabolism. Selenium levels in many soils in many countries has recently been identified as a nutrient deficiency of concern in the UK, Europe, New Zealand, many states in the USA, and in Canada. Selenium deficiency is more common in those on a low dairy diet, or those who have adopted the nutrient poor gluten-free diet.

Selenium deficiency can exacerbate the effects of iodine deficiency [21-25], and has independently been associated with poor

cognitive performance in children [26,27] and poor neurological development [28], developmental delay, particularly if combined with Iodine deficiency [29]. In countries such as New Zealand, and Malawi, which are known to have low Selenium levels in the soils, many women receive less than the recommended daily allowance of Selenium [22,27].

Molybdenum levels in many countries have been steadily declining and molybdenum deficiency is common. Molybdenum deficiency is common in children with sulphite sensitivity, a common preservative in many foods. Molybdenum cofactor deficiency has previously been associated with developmental delay [30], hypersensitivity to sulphite [31], and seizures [32] and neonatal convulsions [33] and encephalopathy [34].

Each of Iodine, Selenium and Molybdenum are essential metals involved in the activation of vitamin B2 to the two biologically active forms, flavin mononucleotide (FMN) and Flavin-Adenine-dinucleotide (FAD). Active FMN and FAD are in turn essential for maintaining the activity of vitamin B12, hence in I/Se/Mo deficiency, active B2 is decreased and functional B12 is reduced (see pathway Figure 2).

Given the importance of functional vitamin B2 in over 100 enzymes, it was of interest to us to determine if mineral deficiencies in Iodine, Selenium and/or Molybdenum could in some way contribute to the dramatic increase in the rate of autism in many countries. To this end, we have obtained Hair Minerals Test Analyses (HMTA) from 250 children with autism and compared their levels to the normal ranges of these minerals in hair.

Methods

Data was pooled from 250 sets of HMTA performed by Doctor's Data Inc St Charles, IL, USA and levels of Iodine, Selenium, Molybdenum, Calcium and Magnesium stratified into various ranges, and percentage of subjects within the ranges calculated and presented in Table form (Table 1). Data is presented as bar graphs (Figures 1a, 1b, 1c).

Results

Analysis of HMTA data from 250 children diagnosed with ASD revealed that a deficiency of one of Iodine, Selenium and/or Molybdenum was very common with every child having a deficiency in Iodine, Selenium and/or Molybdenum in the bottom quartile of the standard range, with many being below and outside the standard range as measured by DData laboratories. Hence for Iodine 17% were below the standard range, with 46.6% low for Selenium and 46.7% low for Molybdenum (Table 1, Figures 1a, 1b, 1c).

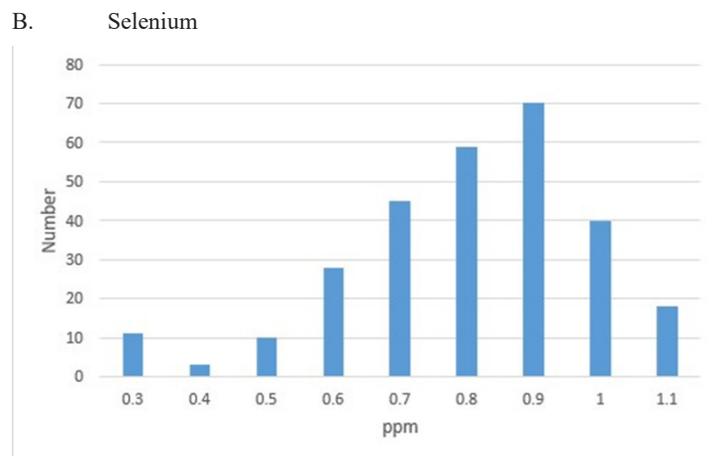
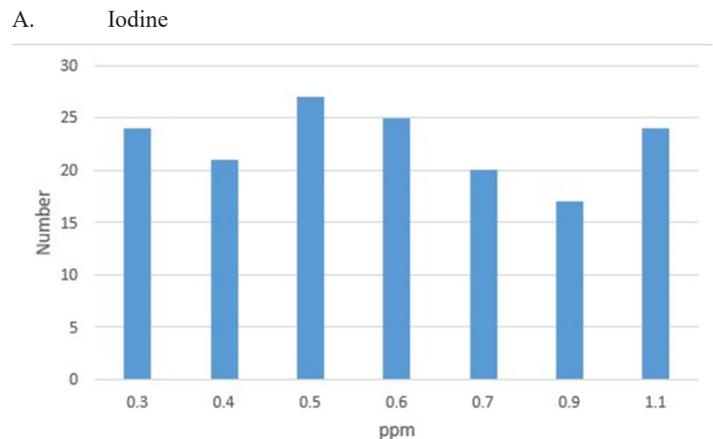
When data was analysed in quartiles children with autism frequently had levels in the lower quartiles of normal:- Iodine (31%), Selenium (82%) and Molybdenum (72%). In our study every child was in the lower quartile for one or more of the metals. Range distribution graphs are plotted for Iodine, Selenium and

Molybdenum (Figures 1, A, B, C).

Table 1: Ranges of Iodine, Selenium, Molybdenum, Calcium and Magnesium from HMTA of children with autism.

Iodine			
Normal range	0.25 – 1.8 ppm		
Autism %			
<0.25 ppm	17%	<0.5 ppm	31%
Selenium			
Normal range	0.7-1.5 ppm		
Autism %			
<0.7 ppm	46.6%	<0.9 ppm	82%
Molybdenum			
Normal Range	0.05-1.3 ppm		
Autism %			
<0.05 ppm	46.7%	<0.07 ppm	72%

Note: Data is represented for children with autism as the percentage of individuals with Iodine levels <0.25 ppm, and <0.5 ppm; Selenium levels <0.7 ppm, and <0.9 ppm; Molybdenum levels <0.05 ppm, and <0.07 ppm.



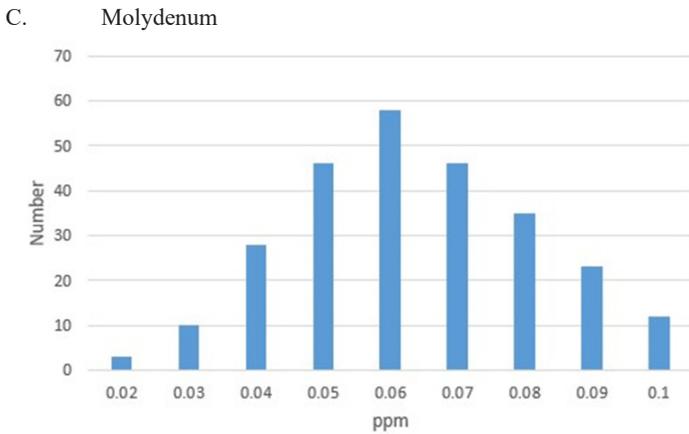


Figure 1: Range distributions of Iodine, Selenium and Molybdenum in HMTA of children with autism.

Discussion

It has been known for many years that vitamin and/or mineral deficiencies in mothers during pregnancy can have disastrous consequences for the neurotypically normal development of the foetus and the newborn child. The identification of folate deficiency as being a risk factor for the development of spina bifida in the neonate, in the late 1980s [35-37] has led many countries to mandate compulsory fortification of foods with folate, which has been accompanied by a 32% reduction in the rate of Spina Bifida in counties such as the USA and Australia [38-41].

Whilst the rate of Spina Bifida has seen a decrease since 1990, the rate of autism has seen a dramatic increase over this time, from 1 in 1000 births, in 1990 to an estimated rate in 2017 of one in every 68 children born in the USA, and in 2024 one in every 30 children born. The rate continues to increase and many other "developed" countries have rates that are similar to the USA, viz: Hong Kong (1 in 27), South Korea (1 in 38), Japan (1 in 55), Ireland (1 in 65) [42]. During the same period there has been a dramatic decrease in consumption of milk from 207 to 150 pints per capita per year in the US, and an increase in the consumption of non-fortified gluten-free produce from 0.1% of the population in 1980 to 25% of the population in 2020 (in the US and Australia). In addition, there has been the adoption of milk substitutes such as soy, and almond drinks. Whilst to many this shift may appear to be innocuous, nutritionally it has serious consequences. Hence, the major sources of Iodine in the diet are Iodinated salt, milk from Iodine supplemented cows, seafood and Iodine fortified bread, whilst the major sources of Selenium in the diet are milk (particularly that obtained from dairies, who have fortified the cows), cereals and seafood. Those who adopt a vegan or vegetarian diet are at risk of Selenium deficiency.

Selenium deficiency can also occur as a result of local soil concentrations and in the US, states such as North Carolina, Kentucky, Pennsylvania, Nevada and South Carolina are known to have low selenium levels [43-45], whilst soils in the UK and much of Europe are also deficient in Selenium [46-50].

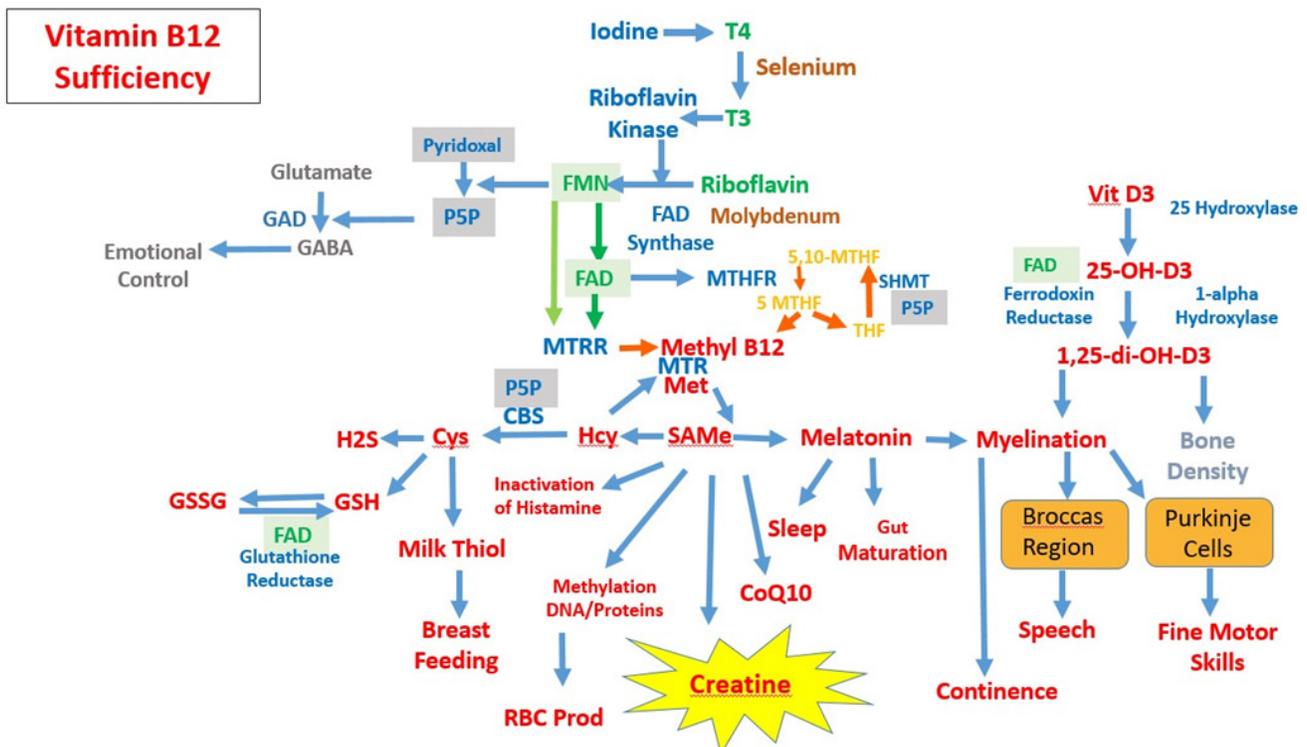


Figure 2: Role of Iodine, Selenium and Molybdenum in the activation of vitamin B2, and the subsequent production of GABA, Glutathione (GSH), Vitamin D, and activation of vitamin B12.

Ranges for Molybdenum in HMTA as measured by DData have also decreased with the standard range in 2000 being 0.05 to 0.13 ppm, which has now dropped to 0.02 to 0.05 ppm, a dramatic shift.

Each of Iodine, Selenium and Molybdenum is involved in the cascade of reactions that are required for activation of riboflavin (vitamin B2) to FMN and then FAD, and hence a deficiency in one or more of the minerals would be expected to result in sub-optimal levels of these two active forms of vitamin B2. Active vitamin B2 is required by over 100 enzymes in the body, and FMN is required for the activation of vitamin B6, whilst FMN and FAD are required for maintenance of methionine synthase reductase (MTRR) and Methylene Tetrahydrofolate Reductase (MTHFR), and hence deficiency of FMN and FAD ultimately will result in the accumulation of inactive vitamin B12.

In separate studies we have examined the levels of functional vitamin B2 and vitamin B12, using Urinary Organic Acids Tests, and found that every child is functionally deficient in vitamin B2 and also vitamin B12. Lack of functional vitamin B12 has been known for over 40 years to result in developmental delay in children. As such we propose that the observed nutritional deficiencies in Iodine, Selenium and/or Molybdenum as being the precipitating factor in causing developmental delay in the children assessed in this study.

Conclusions

A deficiency of one of Iodine, Selenium and/or Molybdenum was found in the HMTA of every child diagnosed with Autism Spectrum Disorder who was examined in this study. Given the known association between deficiencies in Iodine and Selenium and developmental delay, there would be a strong reason to believe that these deficiencies were directly linked to the condition in these children. Of concern is the accompanying observation that not one of parents of the children was aware of the link between these deficiencies and developmental delay. Of even more concern was that despite this link being extremely well known in the literature not one of the health professionals treating the children knew of these links, NOR, had embarked upon treatment of the deficiencies in order to resolve the condition. In this regard, a recent survey in the US revealed that the majority of U.S. obstetricians and midwives....” do not recommend iodine-containing vitamins in women planning pregnancy, during pregnancy, and during lactation” [51]. Such advice by obstetricians and midwives, flies in the face of the fact that Iodine deficiency has been recognized by the WHO as the single most preventable cause of mental retardation in the world and has mandated Iodine supplementation in all countries.

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