Optoelectronic Method for Determining the Aluminium Involved in Symptoms of Attention Deficit Hyperactivity Disorder Children

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Abstract. Aluminum is a chemical element atomic number 13. It is white-silver, insoluble in water under normal conditions. Despite its natural abundance, aluminum has no known biology function. It is a toxic residue, aluminum sulphate having an LD50 of 6207 mg/kg body, corresponding to 500 g per 80 kg person. Extremely acute toxicity without harm to health is of interest in view of the widespread occurrence of the element in the environment and in trade. Toxicity can be tracked after deposition into the bones and the central nervous system and is particularly high in patients with renal insufficiency. In very high doses, aluminum can cause neuro toxicity associated with altered function of the blood-brain barrier.

Keywords: Optoelectronics · ADHD · Urine · Aluminium · GF-AAS

1 Introduction

Aluminum is a chemical element atomic number 13. Aluminum was noted for being a lightweight metal with a density of 2.7 g/cm3. This quality makes it used in large quantities in the naval and aeronautical industries. High reflectivity is used in the construction of metal mirrors [1]. Aluminum is remarkable for its low metal density and its ability to withstand corrosion. Despite its prevalence in the environment, aluminum salts are not known to be used by any form of life. According to its omnipresence, aluminum is well tolerated by plants and animals [2]. Aluminum alloys

O. Fratu et al. (Eds.): FABULOUS 2017, LNICST 241, pp. 218–223, 2018.
https://doi.org/10.1007/978-3-319-92213-3_32

have yield strength ranges ranging from 200 MPa to 600 MPa [3]. Aluminum atoms are arranged in a cubic-centered structure. Aluminum has a stacking energy of approximately 200 MJ/m2. Aluminum is capable of being a superconductor with a critical superconductor temperature of 1.2 K and a critical magnetic field of about 100 Gauss (10 mT) [1, 5].

2 Experimental Set-up

The study aims to make a comparison between the concentrations of urine from the batch of children diagnosed with ADHD compared to those in the "*Children's House SOS Children's Villages*" and to analyze the influence of the sex of the children on the urinary concentrations of aluminum. Determination of the urinary concentration of aluminum was done by the atomic absorption spectrometer with atomization in graphite furnace, (GF-AAS) [3, 4].

2.1 Material and Method

The study was conducted between 2013 and 2014 at the "Children's home - SOS Children's Villages" on a 50-child group divided into two groups:

– A group, consisting of 25 children without ADHD, sex repatriation was: 12 boys and 13 girls;
– B group of 25 children with ADHD, broken down by sex SD follows: 14 boys and 11 girls.

The criteria for inclusion of children in A group were:

– age between 7 and 15 years.

The criteria to exclude children in A group:

– the existence of psychiatric diagnosis (mental deficiency, autism, psychosis, etc.);
– the existence of chronic neurological diseases: paresis, infantile brain paralysis.

The criteria for inclusion of children in B group:

– ages 7 to 15;
– ADHD diagnosis: hyperkinetic disorder accompanied by attention deficit, hyperkinetic disorder accompanied by impulsivity;
– duration of pharmacological treatment prior to inclusion in the group, less than or equal to 6 months;
– the possibility of following outpatient treatment.

Sex was not a selection criterion.
The criteria for exclusion of children in B group were:

– children with ADHD who also have other chronic conditions that may influence the quality of life (neurosis, anxiety, dissociation, organic diseases);
– the presence of mild, moderate or severe mental deficiency;

- the presence of neurological deficits of language reception;
- lack of compliance.

From all subjects enrolled in the study, urine was collected from the spot (10 mL).

To determine the concentration of aluminum in urine specimens, it was used a Varian graphite atomizer coupled with atomic absorption spectrometer system:

- Atomic Absorption Spectrometer (AAS 80);
- Programmable sample dispenser, standards, modifiers and thinner (PSD);
- Water Chiller Model Neslab CFT 33;
- Domnick Hunter Nitrogen Generator;
- Argon - gas cylinder under pressure purity 99.9999%;
- Reagents and equipment specific to a laboratory of analytical toxicology.

2.2 Sample Preparation

In 10 ml of urine harvested from each subject in the study lot, 1 ml of 65% HNO3 was added. The mixture was left in the tube for 20 min and subsequently centrifuged at 2500 rpm for 10 min. The supernatant was the matrix for analysis on GF-AAS.

2.3 Optoelectronic AAS Method for Aluminum

To determine the concentration of aluminum in the injection matrix, the method used for the GF-AAS Varian system shown in Tables 1 and 2.

3 Experimental Results

The average of the urine concentrations of the aluminum was 10.54 µg/L. Sex analysis shows that the average urine concentration in boys was 12.12 µg/L and in girls, the mean was 8.18 µg/L of 1.89. The results are shown in Fig. 1.

Within group B, the mean urine concentrations of aluminum were 10.86 µg/L. Sex analysis shows that the average urine concentration in boys was 12.94 µg/L and in girls, the mean was 8.4 µg/L. The results are shown in Fig. 3. These results show a large distribution of aluminum in urine samples.

These results show a large distribution of urine concentrations of aluminum. The urinary concentration of aluminum allowance for children is in the range 5–30 µg/L [5]. However, the odd Student test shows that the two urinary concentrations of aluminum do not differ significantly statistically for a probability $p > 0.2$. Within group A, the mean urine concentrations of aluminum were 10.2 µg/L. Sex analysis shows that the average urine concentration in boys was 11.16 µg/L and in girls, the mean was 9.24 µg/L The results are shown in Fig. 2. These results show a large distribution of urine concentrations of aluminum.

Sex analysis shows that the value of urine concentrations of aluminum in girls is less than 1.82 µg/L than that of boys. The odd Student Test shows that the two urinary concentrations of aluminum do not differ statistically significantly for a probability $p > 0.6$. Analysis by sex shows that the value of urine concentrations of aluminum in

Table 1. General parameters for AAS.

No.	Parameters	Programming
1.	Type of injection	Auto dilution
2.	Calibration module	Concentration
3.	Type of measurement	Height peak
4.	Standard replicates	2
5.	Sample replicates	2
6.	Smoothing	9
7.	Wavelength	309.3 nm
8.	Slit width	0.2 nm
9.	Lamp current	10 mA
10.	Background correction	Yes
11.	Standard 1	20 µg/l
12.	Standard 2	50 µg/dl
13.	Standard 3	100 µg/dl
14.	Recalibration rate	10
15.	Reslope rate	1
16.	Concentration decimal places	2
17.	Calibration algorithm	New Rational
18.	Replicate % RSD limit	10%
19.	Correlation coefficient limit	0.998
20.	Required detection limit	1 µg/L
21.	Instrument detection limit	0.6 µg/l
22.	Injected volume	15 µl
23.	Sample volume	10 µl
24.	Dilution coefficient	2

Table 2. General parameters for graphite furnace.

Parameter	ST 1	ST 2	ST 3	ST 4	ST 5	ST 6	ST 7
Temp. (^{0}C)	40	85	85	95	120	120	1000
Time (s)	2	5	5	40	40	4	6
Gases	N	N	N	N	N	Ar	Ar
Flow (mL/min)	3	3	3	3	3	3	3
Read	–	–	–	–	–	–	–
Store	–	–	–	–	–	–	–
Parameter	ST 8	ST 9	ST 10	ST 11	ST 12	ST 13	ST 14
Temp. (^{0}C)	1000	2700	2700	3000	3000	40	40
Time (s)	2	2	1	0.1	2	22.3	3
Gases	Ar	Ar	Ar	N	N	N	N
Flow (mL/min)	0	0	0	3.1	3.1	3	0
Read	–	YES	YES	–	–	–	–
Store	YES	YES	YES	–	–	–	–

Fig. 1. Distribution of concentrations of aluminum in urine samples.

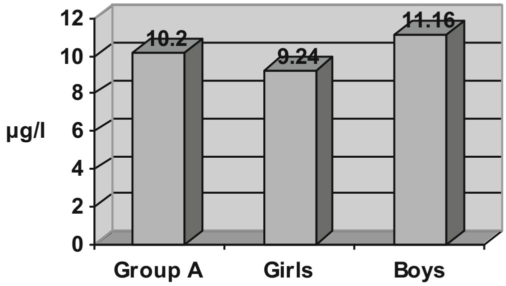

Fig. 2. Distribution of concentrations of aluminum in urine samples of group A.

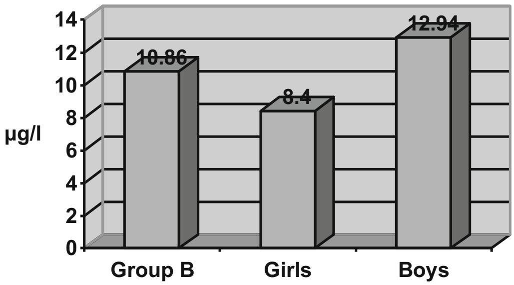

Fig. 3. Distribution of concentrations of aluminum in urine samples of group B.

girls is less than 4.54 µg/L than that of boys. The odd Student test shows that the two media of urinary concentrations of aluminum do not differ statistically significantly for a probability $p > 0.3$. The results are shown in Fig. 4.

The average of urinary concentrations of aluminum in the two groups do not differ statistically significantly for a probability $p > 0.8$. The difference between the two media is 0.66 µg/L. The average of urinary concentrations of aluminum in boys in the two groups do not differ statistically significantly for a probability $p > 0.6$. The difference between the two media is 0.78 µg/L. The average of urinary concentrations of

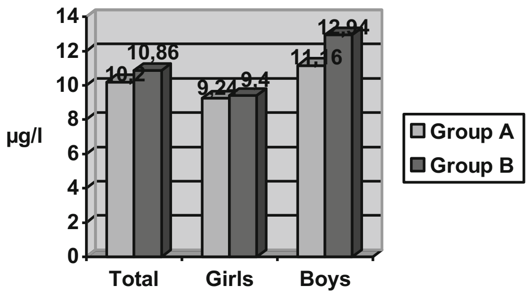

Fig. 4. Distribution of aluminum concentrations of urine samples by groups.

the aluminum of the girls in the two groups do not differ statistically significantly for a probability $p > 0.8$. The difference between the two media is 0.84 μ/L.

4 Conclusions

Analysis of urinary aluminum concentrations in children with ADHD relative to the urinary concentration of aluminum in children without ADHD did not reveal any statistically significant difference.

It can be argued that the occurrence of symptoms characteristic of ADHD can not be correlated with the presence of abnormal values of aluminum in subjects with ADHD.

These results show that aluminum can not be responsible for the presence of ADHD symptoms.

The developed optoelectronic method is relatively simple, reproducible and has a sensitivity that allows analysis of aluminum concentration in urine samples.

No value of urine concentrations of aluminum exceeded the maximum value allowed, which shows that there can be no aluminum contamination of the children in the studied group.

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