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CORRELATION BETWEEN HAIR ELEMENTS AND INTELLIGENCEQUOTIENTIN CHILDREN WITH ATTENTION DEFICIT/HYPERACTIVITY DISORDER

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ABSTRACT

This study aimed to determine the incidence of Attention-Deficit/Hyperactivity Disorder (ADHD) among primary school children in Ulaanbaatar and identify the correlation between their hair elements and intelligence quotient. Attention-Deficit/Hyperactivity Disorder (ADHD) is a disorder that occurs during childhood development, which presents with signs of reduced attention and hyperactivity[1].A total of 973 primary school children 6 – 12 years of age belonging to grades 2 - 5, along with 973 parents/caretakers, and 91 class teachers were recruited from secondary schools of Ulaanbaatar city. Results: Of the total sample of 1200 children, 603 (50.3%) were boys and 597 (49.8%) were girls. Eighty-four children with ADHD were living in the urban city, Ulaanbaatar, Mongolia that indicates the incidence of Ulaanbaatar was 7%. The IQ of children with ADHD group were 85.03±16.86 p<.0001 and the IQ of control group=108.9±21.22, p<.0001.

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INTRODUCTION

Attention-Deficit/Hyperactivity Disorder (ADHD) is a disorder that occurs during childhood development, which presents with signs of reduced attention and hyperactivity (Robert, 2016). Although the cause of ADHD is unknown, there have been numerous studies on the influencing factors. In a meta-analysis of 179 studies worldwide, the prevalence of ADHD was 31% in Europe, 25% in Asia, 26% in the United States of America, and 19% in other continents. Most of these studies were school-based (74%), with only 10% being population-based (Thomas *et al*., 2015). According to the studies between2001 – 2010, the incidence of ADHD was estimated to increase in the United States (US), while remaining relatively stable in Asia, but increased 5% in Europe (Getahun *et al*., 2013; Hoseini *et al*., 2014). Using electronic search engines to identify studies done between2000 – 2013, a meta-analysis of 739 studies estimated the prevalence to be variable, from 0.04% - 24.5% (Nobre, 2017). In the U.S, the prevalence of ADHD in boys increased by 9.9% between 1998-2000 and by 12.3 % between 2007 – 2009, while it increased by 3.6 – 5.5% for girls (Akinbami, 2011). The prevalence of ADHD among school children in the US was reported to be 11% or 6.4 million (Visser *et al*., 2003). Three hundred forty-five ADHD studies conducted in Spain between 1980 – 2011 showed an average prevalence of 6.8% (95% CI 4.9 – 8.8), indicating that the rate increased year by year[8]. Asia and Iran had a prevalence of 7.2% (99/1381), comprising 10.3% (75/727) of boys and 3.7% (24/654) of girls[9]. In the meta-analysis of 2638 studies from 1983 – 2015, the prevalence rate was reported to be 6.26% (5.36 – 7.22) in China, 5.37% in Taiwan, 8.5% in Korea, with it being 2.4 times more common in boys than girls. In terms of clinical subtypes, 3.1% were inattentive (ADHD-I), 0.7% were hyperactive/impulsive (ADHD-H), and 4.7% were combined (ADHD-C) (Wang, 2017; Chan *et al*., 2016; Kim *et al*., 2017). From clinical studies in the US from 2011 - 2013, the prevalence of ADHD increased with age, from 2.7% in children 4 - 5 years of age, 9.5% in children ages 6 – 11 to 11.8% in children12 –17 of age (Pastor *et al*., 2015). In the States, parents were asked how old their children were when they were first told by a doctor or other health care provider

that they had ADHD. The median age at ADHD diagnosis was seven years old, and about one in three children (30.7%) was diagnosed before age 6. Approximately three out of four children (76.1%) were diagnosed with ADHD before age 9[14]. Western studies on the data obtained from WISC-III of specific clinical groups have reported some distinct and reliable subtest and index profiles in childhood neuro developmental disorders, such as autism, and ADHD. A commonly reported Wechsler profile among school-aged children with ADHD includes a lower score on different index (Thiago de Oliveira Pires, 2013). Necessary nutrients, such as trace minerals, including manganese, iron, zinc, iodine, selenium, copper, and chromium, are associated with changes in neuronal function that can lead to adverse effects on behavior and learning (National Research Council, 1989).

MATERIALS AND METHODS

This study was conducted in the city of Ulaanbaatar from March 3, 2018, through December 28, 2018. A total of 973 primary school children 6 – 12 years of age belonging to grades 2 - 5, along with 973 parents/caretakers, and 91 class teachers were recruited from secondary schools of Ulaanbaatar city. A cross-sectional design was used to determine the number of ADHD cases using clinical interviews. Parents were administered the Vanderbilt ADHD Diagnostic Parent for Rating Scale, and classroom teachers were given the Vanderbilt ADHD Diagnostic Teacher for Rating Scale, both formulated by Oklahoma Medical School according to the DSM-IV classification of the American Psychiatric Association to screen for ADHD. The Wechsler Abbreviated Scale of Intelligence (WASI) is a brief assessment battery of intelligence for age 6-89. It consists of four subtests: two assessing verbal skills and two assessing nonverbal reasoning abilities.

These four subtests yield a verbal intelligence quotient (VIQ), a performance intelligence quotient (PIQ), and a full-scale intelligence quotient (FSIQ). We examined VIQ and PIQ independently in our analyses, given that one PIQ subtest is timed and may be influenced by motor speed, which we hypothesized may be lower in children with ADHD. Hair samples were collected following the instruction of the U.S. Doctor's Data Laboratory (https://www.doctorsdata.com/). The history of hair dyeing was reviewed to exclude possible exogenous bio elements that may be incorporated into hair samples. Scalp hair samples were randomly collected from approximately ten sites around both sides of posterior parietal eminences and external occipital protuberance. The hair was cut closest to the scalp by stainless steel scissors. Only proximal parts of hair, approximately 2.5 cm in length, were collected, while the distal parts were discarded. This would ensure that only the recent and uniform period of bio element deposition in each participant's sample was collected. Samples were then packed at room temperature and submitted for laboratory analysis.

Statistical analysis: The most common characteristics of ADHD reported by parents and their child's teachers were analyzed from the questionnaires from parents and teachers to detect specific clinical features. Clinical features that were frequently repeated in both questionnaires from parents and teachers were analyzed to detect specific characteristics of children in Mongolia. After determining that the variables were normally distributed, the chi-square test was performed to determine significant differences in the distribution of the risk factor variables after expressing their incidence as percentages in children with and without the diagnosis of ADHD. Data Analysis Statistical analyses were conducted using SPSS version 22.0 using the appropriate parametric or nonparametric analysis corrected for multiple comparisons. Sample characteristics (e.g., age, gender) and their potential effect on the primary hypotheses of interest were assessed with descriptive and correlational analyses. A p-value of $\leq .05$ was considered statistically significant.

Ethical statements: The study protocol was approved by the Research Ethics Committee at the Mongolian National University of Medical Sciences (Reg. No. 2018/D-10). All participants were informed about the study and gave written informed consent before the study participation. Children with ADHD and their parents were free to continue with their allocation in the ADHD group or control group during the study period or withdraw from the study at any time.

RESULTS

Of the total sample of 1200 children, 603 (50.3%) were boys and 597 (49.8%) were girls. The proportion of the total population comprised by age group was that355 (29.6%)were 7-8 aged, 640 (53.3%) were 9-10 aged, 205 (17.1%) were 11-12 aged, and the average age was 9.22±1.28. Eighty-four children with ADHD were living in the urban city, Ulaanbaatar, Mongolia that indicates the incidence of Ulaanbaatar was 7%. Thirty-four (2.8%) children were living in Ulaanbaatar diagnosed as attention deficit, thirty-one (2.6%) were diagnosed hyperactivity, and nineteen (1.6%) were diagnosed with attention deficit hyperactivity disorders. Diagnosed with ADHD, 77.4% were boys, 22,6% were girls, significantly diagnosed higher among boys. Boys were diagnosed with ADHD 3.6 times higher than girls (OR=3.675, 95% CI 2.276 – 6.210, p<.0001). Children were divided into two groups as children with ADHD group and a control group. Each group had 30 children. The second stage of the study of the 60-second test for the selected was 99.47 ± 22.34 for boys and 86.91 ± 21.06 for girls. This table illustrated that here is a statistical difference between the two groups by Wechsler's scale. Block design (p=.009), vocabulary (p=.0001), and identification (p=.0001). Children with ADHD cannot concentrate while doing work tasks.

The concentration issue is one of the big risks of delay intellectual quotient. The illustration shows the IQ of each group defined by Wechsler's scale. The IQ of children with ADHD group were 85.03±16.86 p<.0001 and the IQ of control group=108.9±21.22, p<.0001. Children with attention-deficit were bad at understanding conversation, speaking the native language, simple words, understanding abilities of the meaning of words scored low. It proved that these children avoid doing IQ work because of lack of concentration. The IQ of children with hyperactivity was higher than other groups (84.53±14.59). We identified hair minerals such as Mg, Zn, Pb, Se, Mn. We have then compared to each group and normal ranges of ages. The graphic shows abnormality of minerals; Mg, Zn decreased, Cu, Pb, Mn Se were increased in the ADHD group. Cu has no statically relevance in both groups. ADHD group and the control group had Pb concentration that was slightly higher and inversely Mg concentration was slightly lower (r=-0.502, p=.005). Concentration of Pb, IQ were direct opposite (r=-0.38, p=.03). Mg level, IQ equally decreased by 50% in the ADHD

group and by 20% in the monitored group. Pb concentration increased, inversely IQ decreased by 50% in the ADHD group. Pb concentration increased and inversely IQ decreased by 30% in the ADHD group

Chan *et al*., 2016; Kim *et al*., 2017). This rate falls within the range of the 5.9 - 7.1% of children reported throughout the world. Worldwide, ADHD is diagnosed approximately three times more commonly in boys than in girls

Table1. Descriptive statistics for WASI-II subtests in children with ADHD and control

	ADHD		Control		P - value
	Average	Standard deviation	Average	Standard deviation	
Block design	15.96	10.96	25.83	16.82	.009**
Vocabulary	19.60	10.0	32.33	12.62	.0001***
Matrix Reasoning	11.60	4.58	15.76	5.11	.002**
Similarities	11.20	6.04	19.23	7.02	.0001***

(*p<.05, **p<.001, ***p<.0001)

Table 2. The concentration of minerals measured in children's hair with ADHD and health group

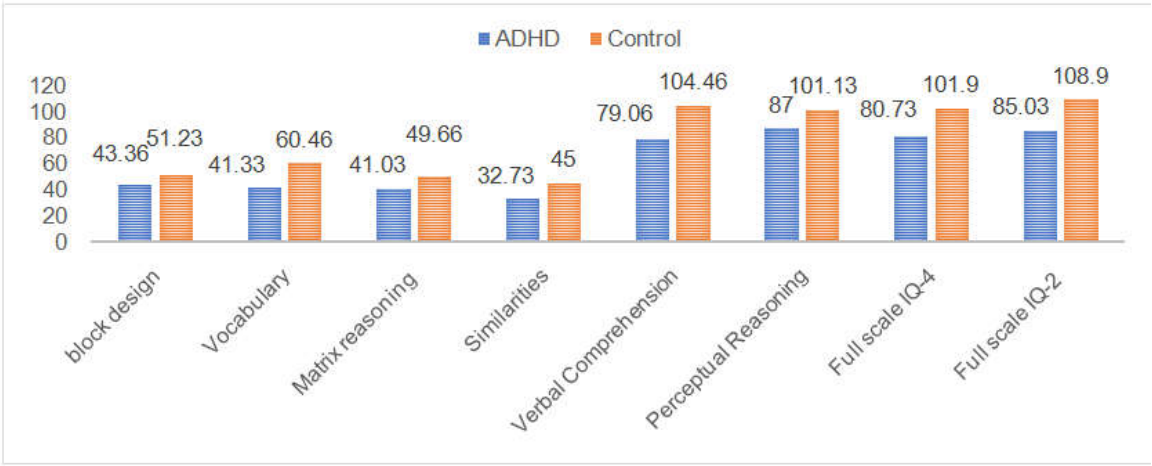
Minerals	ADHD		Control		P-value
	Average	SD	Average	SD	
Magnesium	18.22	2.13	46.63	5.98	.0001***
Zinc	106.41	3.39	119.5	3.31	.008*
Copper	15.77	1.62	14.35	1.07	0.46
Lead	1.4	0.13	0.8	0.08	.001**
Manganese	0.59	0.07	0.38	0.03	.01*
Selenium	1.3	0.13	1.0	0.10	.215

(*p<.05, **p<.001, ***p<.0001)

Table 3. Correlation between hair minerals and IQ in children with ADHD and health group

Levelof element's		ADHD				Control				P-value
		IQ ≤90		91 ≤IQ		IQ ≤90		91 ≤IQ		
		n	%	n	%	n	%	n	%	
Magnesium	Normal	8	26.7	4	13.3	13	43.3	11	36.7	.046*
	Decreased	15	50	3	10	6	20	0	0	
Copper	Normal	11	36.7	6	20	16	53.3	8	26.7	.095
	Decreased	12	40	1	3.3	3	10	3	10	
Zinc	Normal	6	20	1	3.3	12	40	9	30	.258
	Decreased	17	56.7	6	20	7	23.3	2	6.7	
Lead	Normal	8	26.7	1	3.3	10	33.3	11	36.7	.006**
	Increased	15	50	6	20	9	30	0	0	
Manganese	Normal	15	50	2	6.7	14	46.7	10	33.3	0.101
	Increased	8	26.7	5	16.7	5	16.7	1	3.3	

(*p<.05, **p<.001, ***p<.0001)



Picture 1. Descriptive statistics for the WASI –II subtest and index scores in children with ADHD and control

DISCUSSION

In our study, the prevalence of ADHD in Mongolia was 5.8% which is similar with 7.5% in Iran, 5.37% among 7 – 11 year olds in Taiwan, 3 - 5% in other studies among children who are younger than 19 years of age, but is twice the prevalence in boys in Iraq and Korea (Nobre *et al*., 2017; Alizadeh, 2015; The gender ratio in our study was similar. It is reported that this gender prevalence difference may reflect either a variation in susceptibility or that females with ADHD are less likely to be diagnosed than males. As expected, the prevalence of ADHD varied with age. Between the ages of 7 - 12 years, 9-year-old children had the highest prevalence rate (25%) and the lowest rates were seen in the 11-year-old (10.7%) and 12 -year-old

(1.7%) groups. ADHD-I is the most common subtype followed by ADHD-C and ADHD-H in both males and females in the present study. This ordering of subtypes by frequency of occurrence is the same identified in with the meta-analysis by Willcutt (Hanć *et al*., 2018). Our study findings support the hypothesis that high-level, chronic exposure, and deficiency of essential elements is associated with ADHD risk in children.

Conclusion

- 84 out of 1200 children were diagnosed with ADHD. The incidence of ADHD in elementary school children in Ulaanbaatar was 7%.ADHD significantly diagnosed higher among boys. (OR=3.675, 95% interval 2.276 – 6.210, p<.0001).
- IQ was lower in the ADHD group compared to control group 85.03±16.86 p<.0001, monitored group 108.9±21.22, p<.000
- The group with ADHD had lower Mg, Zn, and higher Pb, Se, Mn (p<.0001). The IQ decreased when there was increased Pb and decreased Mg.

Conflict of Interest

The authors have declared that they have no competing or potential conflicts of interest.

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