

Research Article

Comparison between QEEG as a Neurofeedback Tool to Diagnose AD/HD Disorder and Hematological-biochemical Para-clinical Indicators on Children with AD/HD Disorder and Children without Such Symptoms

¹Fatemeh Nimrouzi and ²Ashkan TaghizadehImani

¹Department of General Psychology, Science and Research Branch of the Islamic Azad University (Tehran SRBIAU), Iran

²Tehran Medical University, Iran

Abstract: This research is conducted to achieve two objectives. First, study of clinical suitability and diagnostic precision in paraclinical experiments and study of biochemical factors in the diagnosis of AD/HD and second, study of the effectiveness of blood tests in identification of iron panel factors, study of blood mercury level, study of SE in AD/HD and comparing it with control group (normal children). At the first stage of the study, after analysis by QEEG, all factors to be tested underwent paraclinical experiments. The diagnostic precision of QEEG is estimated at 94%. The results of the first stage demonstrated that the paraclinical experiments are an effective tool with a high diagnostic precision for the diagnosis of AD/HD. The results of the second stage of study demonstrated that both groups suffer from iron deficiency anemia and there is no significant relationship between development of AD/HD symptoms and the iron deficiency anemia. Also the blood Ferritin in the tested group was higher than that of control group. Statistically, no significant relationship was noted between the CBC and development of AD/HD symptoms, yet a significant relationship was observed between reduction of Hb level and development of AD/HD symptoms. It was also concluded that SE stool infection in AD/HD children was higher than that of normal children. In children with AD/HD, vitamin B was less than that of normal children and there was significant relationship between increase in the mercury level of blood and development of attention and concentration deficit disorder (AD/HD).

Keywords: AD/HD, attention deficit, hyperactivity, QEEG

INTRODUCTION

For different reasons, attention to scientific study on the childhood disorders has been increased during the recent years. First, most of children's problems have long run consequences for the child, family and society. Second, most of disorders during the adulthood period originate in the childhood period. Thus, by better understanding of a child's growth process and growth disorders and by progress made in psychology of growth disorder, it is possible to make effective prevention and intervention (Mash and Barkley, 2002).

Attention Deficit/Hyperactivity Disorder (AD/HD) is a chronic disorder which is identified by stable attention deficit with (or without) hyperactivity disorder or impulsive symptoms. Frequency of this disorder in different countries has been reported between 2 and 29%. In the United States, owing to more precise diagnostic standards and wider researches, the frequency of this disorder has been estimated at about 7%.

Without effective treatment, children and youngsters with AD/HD are exposed to risks as

behavioral and educational problems, temperament and anxiety disorders (Biederman *et al.*, 1995) and physical damage and materials misapplication disorders (Claude and Firestone, 1995). Numerous studies have been conducted as to etiology of this disorder and they generally demonstrate that such factors as nutrition, genetics, childcare style and distorted action of brain structures play a role in creating AD/HD. Among the foregoing factors, the most attention has been made to genetics and distorted action of brain structures. Results of conducted studies demonstrate that genetics plays an important role in the AD/HD, such that based on the study conducted on the twins, the inheritability of this disorder is estimated at 0.75 (Willcutt *et al.*, 2000). Meanwhile, in families who one of the children has AD/HD, about 30% of sisters and brothers are diagnosed to have AD/HD (Biederman *et al.*, 1995). Efforts of researchers to find genetic bases of this disorder are concentrated in dopaminergic alleles (adjacent heterogeneous genes).

Studies conducted on the basis of this pattern suggest that reduction in dopamine results from

Corresponding Author: Fatemeh Nimrouzi, Department of General Psychology, Science and Research Branch of the Islamic Azad University (Tehran SRBIAU), Iran

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reduction in the amount of the brain dopamine making areas. Neuroanatomical studies of brain admit such hypotheses.

Based on these findings and compared with normal people, there are structural differences in the brain of people with AD/HD. Owing to two major features of AD/HD disorder, namely disorder in attention and control of actions, the neuroanatomical studies are mostly concentrated on brain regions involved in attention (anterior cingulate gyrus, right frontal region and anterior and posterior regions of the corpus callosum) and control of actions (basal ganglia and cerebellum).

SURVEY OF SUBJECT LITERATURE

Theoretical basics: Conceptual definition of AD/HD problems AD/HD problems refer to a category of problems related to attention deficit, impulsivity, hyperactivity disorder and law breaking.

Operational definition of AD/HD problems: The score for AD/HD problems that is resulted from the sum of scores related to law breaking category and AD/HD symptoms from the children's behavioral list and parents' form (CBCL).

Intensity of AD/HD Symptoms: Intensity and appearance of symptoms in children suffering from AD/HD, based on the blood-biochemical-nutritional status pattern and rate of increase or decrease of serum iron and blood FBS and other factors of biochemical status is in the appearance of hyperactive and attention deficit reactions.

Operation of QEEG system: Electroencephalography is a means to evaluate and measure brain waves and its features. In this method, a certain number of electrodes (generally 19 pieces) which are fixed in a special order and arrangement on a hood are fit on the head and receive brain signals.

Research background: Monastra *et al.* (1996) evaluated ratio of theta to beta that is recorded only from an end point (Cz). By conducting 482 trials (between ages 6 and 30) they evaluated electrical activity of the brain in Cz portion.

Chabot *et al.* (1996) demonstrated that 80% of 407 people suffered from AD/HD, have abnormalities in their own QEEG compared with normal people. Chabot *et al.* (2001) compared 344 children suffering from AD/HD with 245 children suffering from LD. Results showed that QEEG of 97% sensitivity and feature of 84% distinguishes these two groups from one another. Neurophysiological studies to assess relationship between EEG of the brain surface layer and brain sub-structural thalamocortical mechanisms have demonstrated that the fluctuations and changes made in the rhythm and frequency of brain waves are due to

such relationship (Serman, 1996). In neuropathology, by training neurofeedback it is possible to transform abnormal rhythms and frequencies into normal (or relatively normal) rhythms and frequencies. Results of different studies show that although current medicine therapy such as stimulant medicines (Ritalin and Pemoline) and non-stimulant medicines (Atomoxetine and Imipramine) have been able to remedy major symptoms of AD/HD, yet about 25% of patients with AD/HD either have not responded to the treatment, or have been worsened (Kaplan and Gately, 2009). In the studies conducted by Swenson *et al.* (2001) people treated by QEEG, were improved by 98% and moreover, there is no drug side effects in this method (Harrison and Arosio, 2004-2006). In Michigan University the rate of serum iron, Ferritin, FBS in the blood of children with AD/HD was assessed. The obtained results demonstrated that there is a significant relationship between rate of serum iron and the AD/HD symptoms developed in the affected children.

RESEARCH METHODOLOGY

As to the nature of this study which is an assessment research, the variable standard of "diagnostic precision in treatment by QEEG" is considered as the neurofeedback tool and as blood-biochemical correlated factors in the experiment group and the normal individuals as the control group.

In the present research, the aggressive behavior subscales, law breaking behaviors (experience based syndromes) and AD/HD subscale (DSM based) have been used. The aggressive behaviors subscale includes 18 questions, law breaking behaviors subscale includes 17 questions and AD/HD subscale includes 7 questions which are usually and mainly ranked and graded by 0, 1 and 2 scores.

In the CBC test, Mythic kit and Cell counter equipment were used. In the Ferritin test, ELIZA or EIA (Enzyme Immune Assay) method was used. Also in Ferritin serum evaluation, two Immune radiometric sites were used. In mercury and lead experiment, the anemia absorption method was used.

Research hypotheses:

- There is no significant difference between the rate of iron deficiency anemia (serum iron) in the children of 6-16 years old with AD/HD and the rate of blood serum Iron in the normal children.
- Deficiency of vitamin B12 in the body of the children with AD/HD can develop symptoms of this disorder.
- There is a significant difference between the evaluation of iron deficiency anemia and blood FBS in the normal children and tests of FBS and blood serum Iron in children of the age between 6 and 16 regarding development of the AD/HD disorder.

- There is a significant relationship between the state of CBC and blood hemoglobin and the development of AD/HD symptoms in the children of the age between 6 and 16.
- Deficiency of Ferritin in serum Iron of children between 6 and 16 years old with AD/HD, compared to the normal children, can result in development of the symptoms of AD/HD.
- There is a significant difference between poisoning by mercury and development of AD/HD symptoms in the affected children, compared to the normal children.
- Stool infection (SE) in the Scotch test in children suffering from AD/HD, compared to the normal children.

Estimation of population, statistical sample and sampling method: Statistical population of this research included children of the age between 6 and 16 visiting Atyeh General Psychiatric Center, who were initially diagnosed suffering from AD/HD.

Sample and sampling method: Among persons visiting Atyeh General Psychiatric Center, who according to a pre-arranged list were 100 persons (statistical population), 20 children were selected by available sampling method and by the cooperation rendered by their parents. In the first stage of this research, those 20 children were matched with 40 normal children already and initially evaluated by QEEG as a neurofeedback tool and clinically interviewed. In the second stage, 20 children with AD/HD were evaluated by blood test so that their serum Iron, blood sugar, anemia, deficiency of vitamin B12 are studied and stool test was conducted with an aim to assess parasite and stool infection and the poisoning by mercury and lead and the type of blood hemoglobin was studied in the tested group.

Based on statistical processing model and clinical nature of the subject, quantity of sample group and the number of persons assigned in the test and control group was 60 people, from whom 20 people were replaced for in the test group (10 girls and 10 boys) in the control group.

Estimation of validity assessment: Achenbach system of Empirically Based Assessment includes a set of forms to assess competence, adaptive behavior and emotional-behavioral problems. By using such forms, normal data can easily be obtained pertinent to a vast spectrum of capabilities, adaptive behavior and emotional-behavioral problems. Unlike many normalization tests, by use of replied questions and multiple choices, the forms for this assessment system have obtained and reported information regarding the best features and the children's major weaknesses (Achenbach and Rescola, 2001).

The internal stability of Achenbach system of Empirically Based Assessment internal capability scale is equivalent to α 0.63 to 0.79 in CBCL and between

0.55 and 0.75 in YRS and in adaptive behavior scale in TRF is equivalent to α 0.90. Also, the stability of CBCL scores was maintained between 12 and 24 months, YRS scores for 7 months and TRF scores between 2 and 4 months.

In Iran, for the normalization of Achenbach System of Empirically Based Assessment, after making necessary adaptations in terms of language, cultural and social aspects, this list was deployed by use of a multi-stage sampling method and a sample was distributed among 1438 people including 689 girls and 749 boys, based on their educational state and grade in the north, center and south of Tehran and also some individuals visiting Roozbeh Hospital Psychiatric Ward were selected and then different forms of the above system were used in this sample (Minaee, 2005).

Estimation of assessment validity: Validity of test-retest and among the interviewees in CBCL scores, was between 0.93 and 1 for the obtained scores of different interviewees and for parents' reports was a duration of 7 days. Such validity for the scales of competency, adaptive behavior and emotional-behavioral syndrome in CBCL was 0.9.

Methodology:

- **First stage of research:** 20 children with AD/HD and 40 normal children of similar range of age were selected by the available sampling method and based on the assessment, by QEEG tool and clinical interview based on Achenbach System of Empirically Based Assessment.
- **Second stage of research:** 20 children with AD/HD and initial assessment by QEEG, who had been selected in the first stage of research, entered the second stage of the research. It should be pointed out that treatment by QEEG is recognized as a neurofeedback tool. Some patient children took medicine and some other did not take medicine. After performance of initial assessments, children were included in the test group based on being matched by age.

In the present research, blood-biochemical correlations and metabolic disorders in development and assessment of AD/HD symptoms in the children with AD/HD who were assessed earlier by QEEG as a neurofeedback tool with 94% diagnostic precision, were analyzed and compared with control group who included normal children. What explained in continuation hereinafter are the results obtained from analysis of data. Analysis of research is presented in two sections; descriptive findings and analytical-inferential findings and review of research hypotheses.

RESEARCH FINDINGS

ROC analysis was used to assess QEEG diagnostic precision. ROC analysis is a statistical method which is

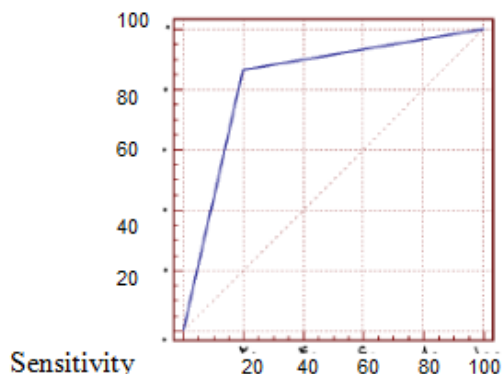


Fig. 1: QEEG diagnostic precision diagram (Sensitivity, specificity)

derived from the signal diagnostic theory and it is intended to evaluate diagnostic precision of the tests (Zweig and Campbell, 1993). Meanwhile, ROC chart can be used to compare the diagnostic performance of two or more diagnostic tests. ROC chart is shown in a form of diagram in which vertical axis is indicative of test “sensitivity” and horizontal axis is indicative of test “specificity”. QEEG diagnostic precision is shown in Fig. 1. Method of calculating sensitivity and specificity is as follows:

$$\text{sensitivity} = \frac{\text{number of true positives}}{\text{number of true positives} + \text{number of false negatives}}$$

$$\text{specificity} = \frac{\text{number of true negatives}}{\text{number of true negatives} + \text{number of false positives}}$$

The more the area covering beneath ROC chart, i.e., the nearer is the chart to the vertical axis, the test will be of a higher diagnostic precision. The area covering beneath the chart which is usually shown by A_z , is indicative of scale distinguishing index. The value of A_z or the area covering beneath the chart is varies from 0.5 (indicative of people’s classification per chance) to 1 (indicative of people’s full and precise classification). Based on an accepted rule, if the values

of A_z are more than 0.85 and 0.90, they are indicative of scale desired diagnostic precision in clinical works. Results of ROC analysis showed that the QEEG in the researched sample is of distinguishing index of 0.83 ($A_z= 0.83$), sensitivity of 0.86 and specificity of 0.80.

Statistical studies and tests: Results of research descriptive statistics are shown in Table 1.

Analysis of data pertaining to hematic-biochemical factors are shown in Table 2 after being evaluated by Hitachi and Eliza equipment.

As it is noted in Table 2, the mean of scores of the tested and control groups under the iron deficiency anemia scale are 30.40 and 34.20, respectively and for the control group are 9.06 and 33.20 respectively.

Also, no significant difference was noted between prevalence of iron deficiency anemia and development of AD/HD symptoms in the girls and boys of tested and control groups ($p<0.05$).

As it is noted in Table 3, the mean of scores of the tested and control groups for the factors of Ferritin, FBS and SI in two tested and control groups are 24.07 and 40.31 respectively.

As it is noted, conduct of t test showed that the difference between mean of Ferritin density ($p<0.001$) and blood sugar density ($p<0.05$) in children based on performed classification is significant, such that the blood FBS in the tested group of children with AD/HD was significantly more than the control group.

Although the difference of serum iron density was not significant, but in the children of AD/HD tested group it was less than the control group.

Analysis of results (research hypotheses):

Hypothesis 1: There is no significant difference between the rate of blood serum Iron deficiency anemia in the children of 6 to 16 with AD/HD and the rate of serum Iron in the normal children.

The normal level of Hb in the tested boys was $Hb<13$ g/dL and in the tested girls was $Hb<12$ g/dL.

Table 1: Descriptive indices pertinent to testable age

Group	Number	Mean	S.D.	Minimum	Maximum
Test	20	11.5	1.25	8	17
Control	40	12.5	2.43	9	18
Total	60	34	3.68	17	35

Table 2: Distribution of iron deficiency anemia in the tested and control groups according to testable gender

Gender	Group AD/HD with ID (%)	Control group without ID (%)	Total (5)
Boy	30 (30.40)	10 (9.06)	40 (100)
Girl	24 (34.20)	36 (33.20)	60 (100)
Total	54 (35.80)	46 (35.5)	100 (100)

ID = Iron Deficiency, $p< 0.05$

Table 3: Analysis of factors Ferritin, FBS and SI in two tested and control groups

Group	Number of n	Ferritin *	FBS **	SI (serum iron)	t
AD/HD	20	24.75±17.76	23.22±10.53	79.21±31.48	24.07
Control	40	43.63±26.22	22.18±9.83	81.39±32.25	40.31

* $p< 0.001$; ** $p < 0.05$

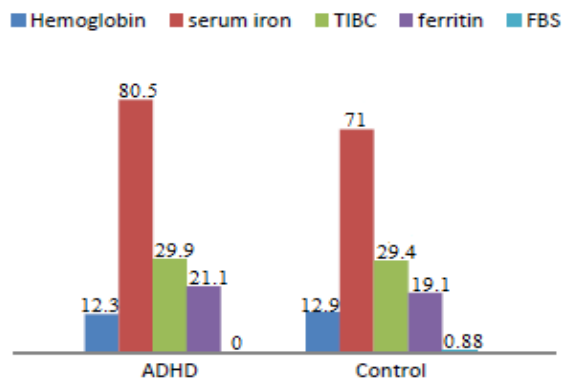


Fig. 2: Schematic view of HB (hemoglobin) levels descriptive analysis

Generally in both genders of tested groups it was less than that figure, which can have significant relationship with the AD/HD symptoms. The schematic results of the tests are shown in Fig. 2.

Hypothesis 2: Deficiency of vitamin B₁₂ in children with AD/HD can result in development of the disorder symptoms.

To assess this hypothesis, hematology indices such as hemoglobin, TIBC and Ferritin in two tested and control groups were evaluated. T statistical test was used to analyze data and to control the effect of hematological indices. Results of the tests are shown in Table 4.

Based on above table, it can be said that ID (iron deficiency anemia) is noted generally in 35% of the

children of the two tested and control groups. There was no significant relationship between the iron deficiency anemia and VBD (vitamin B deficiency) in the researched communication. Even when either of hematological factors such as hemoglobin, serum iron and TIBC, were separately or statistically analyzed, no significant difference was noted between the two tested and control groups in children with VBD and/or without VBD. There was a significant difference between vitamin B deficiency in the children of AD/HD (tested group) and children of control group, because the rate of vitamin B in children of tested group (AD/HD) was less than that of control group. On the other hand, according to data in the above table, it should be said that there is no significant relationship between the iron deficiency anemia and the development of AD/HD symptoms. Hence, it can be concluded that iron deficiency anemia in both two tested and control groups is equally effective.

Hypothesis 3: There is a significant difference between assessment of iron deficiency anemia and blood FBS in the normal children and FBS tests and blood serum Iron in the children of the age between 6 and 16 in development of AD/HD. To assess this hypothesis, the independent t test was used. Table 5 shows results of variables in the tested and control groups. As all value variations are less than 0.50, existence of a multi common linear relationship among factors and the rejection and assumption of a simple linear relationship between the variables were admitted.

Table 4: Results of iron deficiency anemia distribution, hematological indices and deficiency levels of vitamin B in the tested and control groups

Variable	With VBD	%	Without VBD	%	p
With iron deficiency	25	38.5	12	27.3	0.18*
Without iron deficiency	8	6.1	23	52.7	
Hemoglobin + < 11 g/dL	9	6.3	1	2.4	0.45**
Hemoglobin ≥ 11 g/dL	18	9.7	4	8.3	
Serum iron < 50 µg %	6	4.3	8	20.5	0.37**
Serum iron ≥ 50 µg %	4	2.7	13	27.4	
TIBC > 346 µg/dL	14	8.1	4	9.1	0.23*
TIBC ≤ 346 µg/dL	7	5.9	5	7.2	
Ferritin saturation <16 %	3	2.3	15	20.5	0.69*
Ferritin saturation ≥16 %	6	3.6	2	3.6	

VBD = Vitamin B Deficiency; T (hemoglobin<11.5 g/dL in children between 6 and 16 years-old); * x², ** In depend t- Test

Table 5: Analysis of blood serum iron factors for boys and girls individually in the tested and control groups [based on FBS, TIBC, Ferritin (FT), Iron (Fe)]

		AD/HD	Control group	Variations percentage	p-value
Fe (ug/L)	Boys	3.40±1.85	1.09±2.58	+ % 21	0.001
	Girls	3.41±1.01	1.24±2.17	+ % 17	0.001
	Combined	3.40±1.88	1.14±2.43	+ % 19	0.001
Ft (ng/ml)	Boys	18.9±48.3	15.30±74.30	+ % 24	0.001
	Girls	14.6±52.1	13.80±59.20	+ % 6	0.001
	Combined	17.4±36.7	14.20±71.50	+ % 21	0.001
TIBC (µg/dl)	Boys	1.67±0.60	1.39±0.65	+ % 20	0.001
	Girls	1.49±0.44	1.48±0.48	+ % 10	0.001
	Combined	1.63±0.57	1.42±0.60	+ % 14	0.001
FBS (µg/dl)	Boys	5.20±0.44	4.84±1.31	+ % 23	0.001
	Girls	5.03±1.26	5.22±1.52	+ % 25	0.001
	Combined	5.16±1.29	4.97±1.39	+ % 36.3	0.001

Table 6: Mean and standard deviation of Ferritin and age of sample communication in the tested and control groups

	AD/HD n = 40	Control Group n = 20
Mean ferritin (µg/L)	294±172	275±161
Mean age (in years)	15±6.29	41.10±2.17
Ferritin (2000 µg/L (%))	36.83	21.6
2000-4000 µg/L (%)	43	40.6
> 4000 µg/L (%)	35.4	18.1

In 32% of cases, the rate of blood sugar in the children with AD/HD was more from the control group. Thus, it can be said that there is a significant difference between blood FBS level in the tested group and blood FBS level in the control group. Meanwhile, no significant relationship was noted between blood iron composition of both tested and control groups, while blood Ferritin level in the boys of tested group (children with AD/HD) was more higher than the boys in control group (p<0.001). No significant difference was noted between the blood serum Iron level in the girls of tested group and the blood serum Iron level in the girls of control group. Mean and standard deviation of Ferritin and age of sample communication are shown in Table 6.

Based on the data in the above table, it can be said that there is a significant difference between the blood Ferritin serum level in the two tested and control groups, such that the blood Ferritin in the tested group, i.e. children with AD/HD, is significantly more than that of children in the control group.

Hypothesis 4: There is a significant relationship between the CBC status and blood hemoglobin and development of AD/HD symptoms in the children of age between 6 and 16.

By study of this hypothesis and by independent t test, the above hypothesis was approved. Results of variables in the tested and control groups are shown in

Table 7. By analysis of data, it should be said that the CBC is less in the girls with AD/HD compared with the girls in control group and in some cases, this causes the girls with AD/HD to develop aggressive behaviors or attention deficiency and impatience, which can have a direct relationship with development of attention deficiency symptoms in the girls of tested group.

According to above table, hematological factors, i.e., FBS.CBC-TIBC-SI-Ferritin and Hb were analyzed and assessed among the members of the two tested and control groups. Analysis of above data shows that the serum Ferritin level among the boys with AD/HD is higher in comparison than the serum Ferritin level among the normal boys, such that there is a significant and positive relationship between increase in blood Ferritin and development of AD/HD symptoms in the tested group boys compared with the control groups. On the other hand, there was no significant difference between CBC level (anemia) in the tested group girls and CBC level in the control group girls, while there is a significant relationship between CBC (anemia) in the tested and control group and Ferritin in the tested and control group, i.e., when the individual faces anemia, the Ferritin storage is used.

Hypothesis 5: Deficiency of Ferritin in Serum Iron (SI) of children between the age of 6 and 16 with AD/HD, compared to the normal children, can develop AD/HD symptoms.

To assess this hypothesis, Hitachi analyzer equipment 747-200 (spectrophotometer) was used. Table 8 shows results of variables in the tested and control groups. Analyses demonstrate that there is a significant relationship between the low level of serum Ferritin and development of AD/HD symptoms in the tested group children at p<0.01 level.

Table 7: Analysis of hematological factors and ferritin storage

Blood Constituents	Group AD/HD (%)		Control Group	
	Boy	Girl	Boy	Girl
Serum ferritin	0.602**	0.393**	0.314**	0.86*
Serum iron	0.30**	0.38*	0.29*	0.27*
TIBC	0.23	0.14	0.43**	0.56*
CBC	0.70	0.21*	0.32**	0.33
CBS	0.54*	0.48	0.26**	0.21**
Hemoglobin / Hb	0.32	0.39	0.59	0.49**

* Significant coefficient (p<0.05); ** Significant coefficient (p<0.001)

Table 8: Review of comparison between (Ferritin-TIBC-iron) serum iron levels in the tested and control groups

Analyte	AD/HD Group (%)		Control Group	
	Mean %	Pool mean %	Mean %	Pool mean %
Iron Mg/dl (µmol/L)	0.5	121 (21.7)	0.8	119 (21.30)
	0.8	252 (45.6)	1.1	252 (45.10)
TIBC mg/dl (µmol/L)	3.6	81 (14.5)	5.6	108 (19.30)
	1.3	217 (38.8)	4.8	128 (22.90)
Ferritin ng/ml (mg/L)	3.2	46 (46)	2.8	49 (49)
	40.1	400 (400)	2.7	410 (410)

(p<0.001)

Table 9: Analysis of heavy metals samples of mercury (pb) and lead (hg) in the tested and control groups

Metal	Control group n = 40	AD/HD group n = 20
Lead	2.7±1.3	6.7±3.1*
Mercury	0.2±0.15	1.8±1.2

(p< 0.001)

It is concluded from the above table that there is a significant difference between the blood serum Ferritin level in the tested group and the blood serum Ferritin level in the control group, such that in 4.1% of the children with AD/HD in the tested group, the Ferritin level was low (-20 children with AD/HD Disorder, - 4/1% low ferritin). Based on t statistical test, no significant difference was noted at serum Iron plasma levels between the two tested and control age groups of girls and boys, such that the mean of serum Iron in both groups of boys and girls at the age of above 16 years old was generally 150.6 µg 10.mL and in both groups of boys and girls at the age of below 16 years old was generally less than 123.8 µg 100. mL. Thus, there is no significant relationship between the age and serum Iron level.

Hypothesis 6: There is a significant difference between the poisoning by mercury and development of AD/HD

symptoms in the children with AD/HD, compared to the normal children.

This hypothesis was conducted at the significance level of p<0.001. After analysis of data obtained from the tests on children with AD/HD and normal children, it should be said that there is a significant difference between the poisoning by mercury and development of AD/HD symptoms in the affected children compared with normal children, i.e., there is a significant relationship between the increase in the mercury level in blood and development of AD/HD symptoms. Results of calculations are shown in Table 9.

In this study, poisoning by lead and mercury in the children with AD/HD is demonstrated. The above analysis shows that the rate of mercury in the tested group is higher than the control group, such that there is a significant difference between these two groups, i.e., there is a significant relationship between development of AD/HD symptoms and poisoning by mercury and lead, because increase in the level of mercury in blood serum can result in development of impulsive behaviors. Comparison of blood mercury variations in the relation $Ep > 35 \mu\text{g/dL}$ in the blood quantity of tested children group is shown in Table 10.

Table 10: Comparison of blood mercury variations in the relation $Ep > 35 \mu\text{g/dl}$ in the blood quantity of tested children group (AD/HD)

Blood lead (µg/dl)	Optimal Variations in Tested Group			Variations in Relation $Ep \geq \mu$ /dL of Tested Group		
	n ^b	n ^c	%	n ^d	n	%
25<	9	0	0	6	0	0
25-29	29	0	0	16	0	0
30-34	61	10	16	31	10	27
35-39	40	11	28	30	11	37
40-44	19	8	42	16	7	44
45-49	9	4	44	8	4	50
50-54	7	5	71	7	5	71
Total	174	38	22	120	37	31

a: Blood mercury level in the blood test conducted in the quantity of $\mu\text{mol.1}$; b: General mode of children with AD/HD disorder at different levels of mercury. Blood mercury test was not conducted on four tested children; c: General score of children with optimal and appropriate variations and norms at the blood mercury level; d: General score of children with AD/HD disorder at $Ep > 35 \mu\text{g/dl}$ level, with different blood mercury levels.

Table 11: Percentage frequency distribution of the age between 6 and 16 with AD/HD disorder against SE

Test		6-8	8-10	10-12	12-14	14-16	Total (%)
		Number	6	14	24	4	6
Percentage		6	14	23	4	6	100
Control	Number	4	10	12	3	2	100
Percentage		4	10	12	3	2	100

Table 12: Results of independent T test for significance of research hypotheses in the tested and control group

Test	Compared variable	Groups	Mean	S.D.	T	df
Difference significance (SI)	Serum iron	Children with AD/HD	43.28	14.31	4.33	59
		Normal children	44.12	14.52		
Difference significance (Hb)	Hb/elect Hemoglobin	Children with AD/HD	0.36	1.03	3.98	59
		Normal children	0.48	1.41		
Difference significance (SF)	Serum Ferritin (SF)	Children with AD/HD	20.62	10.32	18.16	59
		Normal children	36.21	14.01		
Difference significance (FBS)	FBS	Children with AD/HD	24/21	13.83	10.4	59
		Normal children	12/36	7.42		
Difference significance (TIBC)	Serum Ferritin (SF)	Children with AD/HD	21.36	11.29	10.41	59
		Normal children	21.48	11.32		
Difference significance (CBC)	CBC Anemia	Children with AD/HD	21.36	11.29	10.41	59
		Normal children	21.48	11.32		

(p<0.001)

Owing to the data in the above table, from among 36 children tested by the laboratory with an aim to assess their blood mercury, 52% were of variations appropriate to $Ep > 35 \mu\text{g/dL}$. The blood mercury level in all the children was measured through the venous blood. According to this dual model, it should be said that the ratio of mercury level to blood quantity is 50-54, which is pertinent to the children of 10-16 years of age and above. On the other hand, the percentage of such rate and the relation $Ep > 39 \mu\text{g/dL}$ is also higher. EP in this table refers to the measured blood mercury level in the conducted test. Based on the above analysis, it can be said that there is a significant relationship between the increase in the blood mercury level and development of AD/HD symptoms in the AD/HD disorder. Generally, an upward trend was noted in the increase of blood mercury level in 61% of the tested children group.

Hypothesis 7: There is a significant difference between the SE stool infection in the Scotch Test in the children with AD/HD and the normal children.

This hypothesis is approved by analysis of the tested and control groups children at the significance level of $p < 0.001$ within the age range between 6 and 16 years old. Results of frequency distribution in the tested age groups are shown in Table 11.

Based on the data in the above table, the most percentage in the age group with SE (stool infection) was in the tested group, i.e., children with AD/HD disorder in the age range of 10-12 (24%) and the least percentage was in the age range of 12-14 (4%). Comparisons demonstrate that the mean stool infection (SE) in the tested group with AD/HD is 64 ± 02 and in the control group it is 23 ± 12 , i.e., stool infection (SE) in the children with AD/HD is higher than that of children in control group (normal children). Results of parametric tests for significance difference of compared variables are shown in Table 12.

Results of independent t test for comparison of Serum Iron (SI) in children with AD/HD disorder and normal children demonstrated that there is no significant difference between them as to this variable, thus possibly there is no significant relationship between iron deficiency anemia and development of AD/HD symptoms and there is no difference between SI of normal children and children with AD/HD.

Results of independent t test for comparison of blood hemoglobin (Hb) in children with AD/HD disorder and normal children demonstrated that there is significant difference between them as to this variable, i.e., storage of blood hemoglobin in the children with AD/HD is less than that of normal children.

Results of independent t test for comparison of SF level in the children with AD/HD and normal children demonstrated that there is significant difference between these two groups as to this variable, such that SF of children with AD/HD is significantly less than that of normal children.

Results of independent t test for comparison of FBS level (blood sugar) in the children with AD/HD, compared with normal children demonstrated that there is significant difference between these two groups as to this variable, such that FBS in the children with AD/HD was significantly more than that of normal children.

Results of independent t test for comparison of TIBC level in the children with AD/HD, compared with the normal children demonstrated that there is significant difference between these two groups as to this variable, i.e., blood TIBC level in the children with AD/HD was lower than that of the normal children.

Results of independent t test for comparison of CBC level (anemia) in the children with AD/HD, compared with the normal children demonstrated that there is no significant difference between these two groups as to this variable, i.e., anemia plays no active role in the development of AD/HD symptoms.

CONCLUSION

Owing to comparison made between a tested group, i.e. children with AD/HD and a control group, this study is considered a rare experiment on the effect of diagnosis and assessment of AD/HD symptoms by paraclinical and hematological tests. Results of present research findings demonstrated that the quantitative electroencephalography (QEEG) analytical method not only is a method of high diagnostic precision, but also it can be helpful as a supplementary tool to diagnose AD/HD.

In the analysis of results, it was concluded that there is no significant difference in the distribution of iron deficiency anemia among girls and boys in the tested and control groups. Meanwhile, by assessment of girls and boys in the tested group, it was concluded that there is no significant relationship between iron deficiency anemia and development of AD/HD symptoms. This finding contradicts the findings of Lubar and Barkly (2002).

In 25% of the tested cases, increase in the blood sugar (FBS) was also noted. This conclusion only conforms to the findings obtained from this method by studies conducted by Bradly *et al.* (2003). In both groups, 32% of the children also showed increase in FBS (blood sugar). Studies made by Ching Hoo (2004) are also indicative of increase in blood sugar in some of children.

Another point to be mentioned is that by making comparison, the storage of blood hemoglobin (Hb) in the girls with AD/HD is less than that of the control group (normal) and this factor sometimes develops aggressive behaviors and/or attention deficiency and impatience in the children with AD/HD, which would have a significant relationship with the development of attention deficiency symptoms. Results of present research on Ferritin serum level in development of AD/HD symptoms are similar to studies made by Tansey *et al.* (2007) and Lubar *et al.* (2004). In this study, Ferritin serum level in the children with AD/HD

was also lower compared to that of the other children. Meanwhile, there is a significant relationship between the low level of Ferritin serum and development of AD/HD.

As to assessment of CBC rate or anemia in the children with AD/HD, compared to the normal children, it can be said that there was no significant relationship between the development of AD/HD symptoms and decrease or increase in the rate of anemia in the children with AD/HD disorder. But, there is a significant relationship between CBC or anemia and increase in blood Ferritin level, i.e. upon development of anemia, the individual uses the stored Ferritin.

Proposal:

- This research was launched for the children of the age between 6 and 16 years old. Results of the present research can be compared with and analyzed against other age groups.
- In the future researches, the difference of other biochemical factors and elements in the effectiveness and results of the present paper method can be compared and analyzed.
- Future researches in which placebo group is also present, can better characterize and analyze the clinical benefit of paraclinical experiments and assessment of biochemical factors by removal of placebo effect.
- In development of symptoms and also study of its intensity, other researches can examine analysis of the other blood factors.

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