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A Comparison of Frontal Lobe Function Between Students with Attention- Deficit Hyperactivity Disorder and Normal Students

Nasser Sobhi Gharamaleki,[1] Rasol Roshan,[2] Saeed Pourabdol,[2,*] Shahrzad Saravani,[3] and Gholam Hossein Ghaedi[4]

[1]Department of Motor Behavior and Sport Psychology, Faculty of Physical Education and Sport Sciences, University of Allameh Tabataba'i, Tehran, Iran
[2]Department of Psychology, Faculty of Human Sciences, Shahed University, Tehran, Iran
[3]Department of Educational Psychology, Faculty of Humanities, Islamic Azad University of Qom, Qom, Iran
[4]Department of Psychiatry, Faculty of Medicine, Shahed University, Tehran, Iran

[*]*Corresponding author*: Saeed Pourabdol, Department of Psychology, Faculty of Human Sciences, Shahed University, Tehran, Iran. E-mail: saeed.pourabdol@yahoo.com

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Abstract

Background: Attention-deficit hyperactivity disorder is among disorders that has attracted the attention of many psychologists, psychiatrists, and researchers. The results of different researches have showed that the frontal lobe plays an important role in the incidence of this disorder and its continuity; therefore, the aim of the present research was to compare between frontal lobe function of students with attention-deficit hyperactivity disorder and normal students.
Methods: This research was descriptive and causal-comparative. The research population included all third-grade high school male normal students and those with attention-deficit hyperactivity disorder in Ardabil city (2015), from which 60 students (including 30 normal students and 30 students with attention-deficit hyperactivity disorder) were selected through multi-step cluster sampling. For data collection, Conner's adult ADHD Rating Scale-Self report form and subscale, subtests of similarities, mazes, Wechsler's picture regulation, and Wisconsin's cart sorting test, tower of London test, and diagnostic interview based on diagnostic and statistical manual of mental disorders (DSM)-5 were used.
Results: The results of multivariate of variance analysis (MANOVA) showed that there was a significant difference between frontal lobe function of students with attention-deficit hyperactivity disorder and normal students. On the other hand, the function of frontal lobe among students with attention-deficit hyperactivity disorder was significantly weaker than normal students ($P < 0.001$).
Conclusions: The obtained results showed that functions of frontal lobe, such as inhibition behavior, social judgment, abstract reasoning, planning, and other functions related to this lobe among students with this disorder was weaker than normal students; hence, it is necessary to take measures in order to improve their psychological health through suitable treatments, such as cognitive-behavioral therapy with emphasis on cognitive remediation, correcting cognitive distortions, and training behavioral techniques.

Keywords: Attention-Deficit Hyperactivity Disorder, Frontal Lobe, Students

1. Background

Attention-deficit hyperactivity disorder (ADHD), which is a disorder in growth and nervous system and is among the most common childhood disorders, has attracted the attention of many psychologists, psychiatrists, and clinical experts. Children with attention-deficit hyperactivity disorder make up nearly 40% of all children, who refer to psychological health centers. The symptoms of this disorder were primarily described by Henrik Hoffman in 1845 (1). The main characteristic of this disorder was the constant pattern of attention deficit and/or impulsive/hyperactivity, which is higher and more severe in comparison to others at the same growth level in a way that leads cases to exhibit socially unacceptable behaviors that endanger social positions. On the basis of diagnostic and statistical manual of mental disorders (DSM)-5 for diagnosing symptoms of attention deficit/hyperactivity disorder, such behavior must be present for six months among children before 12 years old and five months among teenagers and adults. The common definition of ADHD includes 18 behavioral symptoms, which are divided to two nine-symptom sets; attention deficit and hyperactivity-Impulsivity (2). This disorder is associated with other problems, such as educational performance, weak relationship with family and friends, low psychic health, and drug abuse at younger ages (3).

The prefrontal cortex is part of the frontal lobe, which is responsible for important activities and functions of the human brain. This part of the brain is one of the

largest parts of the brain, containing almost 10.6% of its weight (4). This part of the brain is in mutual association with other parts, such as the limbic (motivational) system, reticular activating (arousal) system, posterior association cortex (cognitive/perceptive and knowledge based processes) and motor (action) system of the frontal lobe (5). The frontal lobe is naturally responsible for controlling and regulating emotions, and produces responses; this is done through brain mechanisms of the limbic system, such as the amygdala. If this part of the brain is malfunctioned, people could hardly control and revise their aggressive behaviors, thus the probability of impulsive aggressive behaviors would be increased (6). Executive cognitive functions, such as language and speech, and reasoning and planning, which include other functions, such as controlling impulsive behaviors, attention and concentration, thinking, perceiving time, social decision making, and information processing, voluntary movement activities, storing movement patterns and activities, emotional and personality characteristics etc. are among the main functions of prefrontal and frontal areas (4). Nearly 80% of children with attention-deficit hyperactivity disorder have at least some malfunctioning in one of the functions of the frontal lobe (7). These children have more problems with certain functions, such as attention, attention span, sustained attention, inhibition, planning and organizing, and working memory (8, 9). A review of studies revealed that frontal lobe function plays an important role in attention deficit hyperactivity disorder. Barkley at el. (10), through reviewing neuropsychological studies related to frontal lobe function in children with ADHD, found that most of these studies and tests tried to evaluate the ability to control response, which seems to be done through the frontal lobe, especially orbitofrontal, medial frontal, and also through its many connections with the striatum (10). In other researches, researchers found that people with ADHD were more susceptible to disorder in behavior control than normal people and people with ADHD due to deficits in response inhibition were unable to provide a suitable and in time response (11). Some other researches indicated that cognitive, educational, and emotional problems among people with ADHD are more common than normal people and those with this disorder cannot concentrate, experience attention deficits, and are unable to keep constant attention (12, 13).

The obtained findings and the mentioned descriptions about the role of the frontal lobe indicate its importance and in case of any deficit in this part of the brain it might have some malfunctions; hence, learning more about this disorder, its cause and preventive measures, is important. Therefore, this research attempted to determine whether the function of the frontal lobe is different between students with ADHD and normal students.

2. Methods

This research was descriptive and causal-comparative. The research population included all third grade high school male normal students and those with attention-deficit hyperactivity disorder in Ardabil city (2015); in this research, firstly, ten male high schools were selected through random multi-step cluster sampling and then two classes were selected from each school randomly. By explaining symptoms of attention deficit/hyperactivity disorder to the teachers, the researchers identified and selected those, who showed symptoms of such disorder. Then, for exact identification of ADHD students, diagnostic interviews with regards to the DSM-5 criteria and Conner's questionnaire, were conducted. Finally, 57 subjects were identified with this disorder, and among them, 30 subjects were selected randomly as the research sample; then, 30 normal students with the same age and educational level were selected as the control group from those at high schools. It is noteworthy to mention that the minimum number of sample in the causal-comparative method must be 15 subjects, yet for increasing external validity, the researchers selected 60 subjects, 30 subjects with ADHD and 30 normal students (14).

2.1. Research Tools

For data collection the following tools were used:

Structured clinical interview on the basis of symptoms in DSM-5: In this research for identifying symptoms of attention deficit/hyperactivity disorder, the researchers used structured clinical interviews on the basis of symptoms described for ADHD in DSM-5 (2).

Conner's adult ADHD rating scale- self report form and subscale (CAARSS: S): This scale is a form of self-report developed by Connerss, Erhardt, and Sparrow (15). Responses to the 26 items of this questionnaire were scored on a four-point scale format ranging from 0 to 3. The raw scores of this scale were turned into T-scores, using a suitable normative table (in this scale, T-scores had an average and standard deviation of 50 and 10, respectively). T-scores above 65 were significant clinically and T-scores above 80 showed problem intensity and the pathology of that area and indicated its malformation or exaggeration in symptoms (15). This questionnaire has not been not normalized in Iran; yet, in their primary studies on 20 subjects Arabgol, Hayati, and Hadide (16) obtained its reliability through Cronbach Alpha (0.81) and its external validity was confirmed by three specialists in the related area. The questionnaire developers reported its reliability from 0.85 to 0.95 and its validity from 0.37 to 0.67 (15).

Wechsler test (WAIS-III): In 1930, Wechsler started to study some standard tests and selected 11 subtests for developing his first scale. The revised version of Wechsler adult intelligence test was published in 1988. This test is applied for identifying patients with and without brain dysfunction. The validity and reliability of the triple scales of Wechsler adult test were generally high. Wechsler reported that the values of two halves of the test validity for total scale IQ, verbal scale IQ, and practical scale IQ were 0.97, 0.97, and 0.93, respectively. The obtained Cronbach's alpha for picture arrangement and similarities subtests were 0.85 and 0.89, respectively (17).

Picture arrangement subtest: This test includes ten cards with printed pictures on them. In each test, some cards with scrambled order are given to the participants, who are asked to put them in order and make the story meaningful. The numbers on the backs of the cards show left to right order of presenting them to the participants. The printed letters on the backs of the cards is the numbering key. A time is allocated for answering each item. The test would be stopped after four successive incorrect answers. The maximum score in this test was 20.

Similarities subtests: This test requires verbal conceptualization and abstract reasoning and includes 14 items (questions). Participants are asked to state the similarities between the two presented items. The test is stopped after four successive incorrect answers. With regards to the presented descriptions, each item will be scored two or zero.

Maze subtests: Some activities, such as planning, conceptual organization, visual-motional consistency, rapidity, and verbal reasoning can be done through this test. Coefficient of validity in this test was reported between 0.82 and 0.88. Shahim (18) reported its coefficient between 0.60 and 0.84 among Iranian children (18).

Wisconsin Card Sorting Test: This is a neuropsychological test applied for measuring proficiencies, such as problem-solving, sorting, abstract thinking, and the ability to keep concepts and cognitive flexibility, which are related to the function of brain frontal lobe (19). Studies related to regional cerebral blood flow (RCBF) through positron emission tomography (Spect-PET) have showed that there is a relationship between deficiency in responding to Wisconsin test and deficiency in the function of the frontal lobe (20). This test is one of the most sensitive tests related to the frontal lobe and parietal-lateral lobe. The validity of this has been reported as well over 0.86 by Lezak (21) for evaluating cognitive disorders, resulting from brain damage (21). According to the coefficient of evaluators' acceptance in a study conducted by Esprin and Estrous (22), the reported reliability was 0.83.

Tower of London Test: This was developed by Shallice (23) with the aim of evaluating planning ability of patients with frontal lobe damage. Subjects are asked to replace a set of colorful nuts in three vertical rods to match them with a specific goal. In each test, upper arrangement never changes, which shows target arrangement and lower row includes segments that must be rearranged to be matched with upper arrangement. Target position for segments is variable, yet the starting point will be fixed. The problem would be solved with two, three, four, and five movements, which are in fact the minimum number of movements (24). The used indicators include a) total administering time, b) total copying time, and c) total acquired score by the subject (25). Shallice reported that those with left frontal lobe damage (especially during work space, and before start) spend more time on the matching model than the control group (normal people).

Method of Conducting Research: After obtaining the required permission from Ardabil Education and informing and satisfying subjects with observing all ethical issues (such as assuring privacy of information and giving freedom of choice to participate in the research), students with ADHD were identified. After explaining the research goals to the subjects, the testes (Wechsler, Wisconsin and London Tower tests) were administered and they were asked to complete each test carefully. The required information was collected individually from the related high schools. Finally, the collected data were analyzed through multivariate analysis of variance (MANOVA).

3. Results

As demonstrated in Table 1, the mean score (SD) of students with ADHD in the subtests of picture regulation, similarities, maze, Wisconsin Perseveration illusion, sorts of Wisconsin test, and total score of London Tower were 5.08 $\pm$ 1.22, 4.15 $\pm$ 1.03, 5.61 $\pm$ 1.34, 41.27 $\pm$ 2.65, 2.23 $\pm$ 0.53, and 19.18 $\pm$ 1.03, respectively. Means and standard deviations of normal students were 7.86 $\pm$ 2.03, 7.20 $\pm$ 2.43, 6.44 $\pm$ 2.60, 21.61 $\pm$ 2.55, 4.50 $\pm$ 2.80, and 28.78 $\pm$ 3.40, respectively. The results showed that the mean score of students with ADHD was lower than that of normal students. On the other hand, the results indicated that functions related to frontal lobe in ADHD students were weak.

Before using multivariate analysis of variance for observing the hypotheses, the researchers used tests of Box and Leven. On the basis of Box's test, which was not significant for any variable, the equality condition of variance/covariance was observed correctly ($P = 0.365$). On the basis of Leven's test, which was not significant for any variable, the equality condition of intergroup variances was observed.

The results of Wilkes' lambda test (Wilkes' lambda = 0.598, $F = 96.251$, $P > 0.001$) showed that there was a mean-

Table 1. Mean and Standard Deviation of Wechsler, Wisconsin and London Tower Tests Among the Two Groups[a]

Major Test	Students with ADHD	Normal Students
Wechsler		
Picture regulation	5.08±1.22	7.86 ± 2.03
Similarities	4.15 ± 1.03	7.20 ± 2.43
Maze	5.61 ± 1.34	6.44 ± 2.60
Wisconsin		
Perseveration illusion	41.27 ± 2.65	21.61 ± 2.55
Sorts	2.23 ± 0.53	4.50 ± 2.80
London tower		
Copying time	134 ± 2.34	101.11 ± 1.56
Administration time	154 ± 3.30	120.23 ± 2.71
Total score	19.18 ± 1.03	28.78 ± 3.40

[a]Values are expressed as mean ± SD.

ingful difference between the two groups under study, based on the order of their dependent variable. For determining, which dependent variables define the meaningful difference between the studied groups the researchers considered the results of single-variable analyses.

As shown in Table 2, there was a significant difference between the two groups in the subtests of picture regulation (F = 29.21), similarities (F = 26.76), maze (F = 18.19), London Tower (F = 28.65), Wisconsin perseveration illusion (57.64), and sorts of Wisconsin test (21.29). On the other hand, the results indicated that frontal lobe function in ADHD students was weaker than normal students.

4. Discussion

The aim of the present research was to compare the function of frontal lobe between students with ADHD and normal students. The results indicated that there were some differences between the two groups in the functions of frontal lobe. On the other hand, students with ADHD showed weaker functions than normal students. These findings, which are in line with the findings of other researches (8, 9, 11-13) conducted in this area, indicate that functions, such as attention, concentration, behavioral inhibition, cognitive processing, and planning are weak in ADHD cases. In this research, students with ADHD showed more Perseveration illusion in Wisconsin's test. Perseveration illusion is the main indicator of WCST in evaluating deficiency of frontal lobe (26). Generally speaking, perseveration illusion is the repetition of a pre-learned response against a new stimulus. Hence with regards to the obtained results, which show the percentage of executive function and deficiency in the frontal lobe, it could be said that students with ADHD experience frontal lobe malfunction. The finding is also in line with that of Gubillo et al. Their aim was to study the difference in cerebral functions of frontal lobe through FMRI and through given assignments, related to cognitive change and cessation. Regression analysis showed that adults, who had been recognized with ADHD during their childhood showed less activities in comparison to the control group in their subcortex, thalamus, and left parietal lobe during both assignments. Moreover, in stop sign test, they show fewer activities in neuron networks of right inferior-superior, striped, and parietal convolutions. Research findings showed that adults, who had been recognized with symptoms of ADHD in their childhood and such behavioral symptoms have continued throughout their life showed a significant pattern of malfunction in their parietal and striped frontal lobe during the assignment related to inhibition control (27). Studies related to evoked potential and functional magnetic resonance imaging (FMRI) indicated that people with ADHD show a decrease in activities of primary positive and negative amplitudes; as it can be seen through FMRI, a decrease also occurs in activities related to executive network of frontal-parietal lobes (28).

Moreover, the obtained results showed that students with ADHD are of some deficiency in functions related to their frontal lobe, such as executive function, codifying, planning, and emotion regulation. These findings are in line with that of Barkley (29), who believed that weakness in time perception, working memory, and internal speech, and also the failure of self-regulation/motivation/excitement will lead to fundamental weakness in sustainability goal-oriented behavior in people with ADHD. This is the reason why these children act like normal children in continuous reinforcement plans yet they show some malfunctioning in partial reinforcement plans, because they can't guide themselves to a (bigger) re-inforcer through self- regulation, foresight, and internal speech. Researches have shown that students with ADHD are weaker than their peers in writing, drawing, and speaking. Moreover, children with ADHD are of weak and inefficient motorial organization and they learn to walk later than their normal peers and they also show some visual-motorial perception problems in compound (30).

4.1. Conclusion

All in all, it can be said that people with attention deficit/hyperactivity disorder experience some malfunctioning (executive dysfunction) in their frontal lobe. These malfunctions include hyperactive, inattention, distraction, impulsivity, lack of order, planning, and emotional

Table 2. The Results of Multivariate Variance Analysis Based on Mean Scores of Wechsler, Wisconsin, and London Tower Tests Among the Two Groups

Dependent variable	SS	df	MS	F	P Value
Wechsler					
Picture regulation	331.52	1	331.52	29.21	0.001
Similarities	234.45	1	234.45	26.76	0.001
Maze	289.27	1	289.27	18.19	0.001
Wisconsin					
Perseveration illusion	507.44	1	507.44	57.64	0.001
Sorts	230.21	1	230.21	21.29	0.001
London tower					
Copying time	6731.22	1	6731.22	16.67	0.001
Administration time	6123.49	1	6123.49	14.39	0.001
Total score	342.76	1	342.76	28.65	0.001

control. If not treated in time, such deficiencies may have intensive and unpleasant consequences. This does not mean that such people can never gain suitable cognitive-behavioral functions. Of course, some effective medical treatments along with some psychological treatments can play an important role in improving such disorder; hence, it seems necessary for psychologists and psychiatrists to consider these studies in dealing with such disorders. This research was limited to Ardabil city so this is one of the limitations of the research. Furthermore, the research subjects were only male third grade high school students with ADHD, which limits the generalization of the research results. Hence, it is suggested to be perform similar researches in other cities and regions of Iran; also, it is suggested to conduct this research with other age and/or gender groups to generalize the results with more certainty.

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