Phonological Processing and other Language Parameters in ADHD Children

Original Article

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ABSTRACT

Background: Attention Deficit Hyperactivity Disorder (ADHD) refers to the existence of marked difficulties in terms of distractibility, impairment of attention and hyperactivity with a subsequent development of substantial impairment in academic and social functioning. Language impairment (LI)is a predominant co-morbidity in pediatrics with psychiatric illnesses and behavioral troubles. In children with LI, one of the common psychiatric disorders is ADHD. However, LI is a common co-morbidity which often could be detected in ADHD children. Although language problems are not among the main symptoms or needed to fulfill current diagnostic criteria of ADHD, most ADHD children have additional defects in language skills.

Objective: The main purpose of the current study was to assess language profile in ADHD children at school age and to specify aspects of language defect in comparison with their normal peers.

Patients and Methods: 60 children in the school age (6-10 years) of both genders divided in to two groups, case group: 30 children with ADHD and control group: 30 children without ADHD were enrolled in this case control study.
Children were assessed by study tests: 1- Stanford Binet [fifth edition], 2- ADHD Test 3- REAL Scale, 4- Phonological Awareness Test, 5- Rapid Automatized Naming Test.

Results: ADHD children were lower than their normal peers in IQ score, language skills, phonological awareness skills, and rapid automatized naming. Regarding aspects of language, they had defects in many skills: receptive and expressive vocabulary, morphosyntax, sentence comprehension, story comprehension, verbal categorization, sentence repetition, and forming sentences.

Key Words: ADHD, language, phonological awareness.

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INTRODUCTION

1.1. Background:

ADHD is a frequent, treatable pediatric psychiatric disorder, featured by manifestations of improper attention, motor restlessness and impulsivity which affect about 4.5% of school-aged children[1]. Prevalence is about 5% for children and adolescents and about 2.5% for the adults[2,3]. Boys with ADHD out number girls, but percentage differs markedly from 2:1 to 9:1. Boys are more likely to be aggressive and to show more hyperactivity and impulsivity. Girls might present with a less severe form of ADHD. They present mainly with ADHD (in attention subtype). They usually demonstrate low levels of disruption and hyperactivity and their manifestations might not be clear so their issues might be missed by parents as well as school teachers[4, 5].

1.2. Diagnosis of ADHD

ADHD has 3 major manifestations clusters – inattention, hyperactivity, and impulsivity. ADHD presentation might differ in terms of age and developmental phase and there are cultural changes in activity level and improper attention which are considered as major problems[6]. Diagnosis needs obvious proof of clinically substantial impairment in social, academic, or occupational functions. The most common inattentive kind is comparatively common in girls. In the predominantly hyperactive-impulsive kind, children demonstrate high degree of aggressiveness and impulsiveness. In addition, they are refused by their friends. The combined type induces more defects in global functioning, when compared to the remaining types[7].

DSM 5 diagnostic criteria for ADHD children[2]:

A: A persistent pattern of improper attention and/

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or hyperactivity-impulsivity which affects functioning or development as featured by improper attention and/or hyperactivity/impulsivity.

Inattention: 6 criteria or more of the following (if 17 years or older, only 5 needed):

● Frequently has no ability to give proper attention to details or performs careless faults.

● Frequently has no ability to sustain attention in tasks.

● Does not demonstrate attention when spoken to in a direct manner.

● Frequently does not obey the instruction, in addition, fails to end schoolwork alone.

● Frequently has difficulty to organize any task.

● Frequently avoids works necessitating mental efforts.

● Frequently loses things.

● Easily distracted.

Hyperactivity and impulsivity: Six criteria or more of the next (if 17 years or older, only 5 needed):

● Frequently plays with hands.

● Frequently leaves seat.

● Frequently inappropriate runs or climbs.

● Has no ability to play in a quite manner.

● Talks in an excessive manner.

● Blurts out answers prior to the question isended.

● Frequently has difficulty waiting his/her turn.

● Frequently intrudes on others.

B: A lot of inattentive or hyperactive-impulsive manifestations were present before the age of 12 years.

C: A lot of inattentive or hyperactive-impulsive manifestations are present in two or more settings (such as at house, schools, or workplaces).

D: There is obvious proof that the manifestations interfere with social, academic, or occupational functioning.

E: Manifestations do not develop exclusively during schizophrenia or are not better clarified by additional mental disorder.

1.3. Language and ADHD

Language consists of 3 intersecting areas: content, form, and pragmatics. The three areas are similarly important, and problems might arise due to defects within any of them[8]. Although Language impairment (LI) are not between the main symptoms or needed to fulfill current diagnostic criteria of ADHD, most ADHD children have further defects in language skills and in core numerical abilities[9, 10]. Studies have shown that about 60% of ADHD children have LI which might go undetected unless their language skills are assessed in a systematic level[11]. Epidemiologic research which uses standardized language test batteries expected that substantial levels of LI could be co-occur in 43% of children with ADHD may rate up to 90% in research utilizing clinically referred specimens[10]. In a cohort study on 3208 children aged between 6 and 11 years, they recognized a considerable overlap between LI and attention deficit disorder (ADD) that is in accordance with prior out comes from clinical specimens, 45% of the children fulfilled the criteria for both diagnoses[8]. In line with this, impairments in language skills were reported in 67% of a clinical sample of 76 children (average age 11 years) diagnosed with ADHD[12]. When compared to classically developing children, children with ADHD are at a higher possibility for a lot of markers of LI such as delayed onset of 1st words and word combinations, discourse limitations producing cohesive narratives and pragmatic difficulties accompanied by improper conversational contribution[10]. Another study said that cases with ADHD were found to be considerably slower and less effective in comparison with the controls in terms of complex sentence comprehension[13]. Subclinical language deficits, especially in terms of comprehension, syntax formulation, and pragmatics, have often been recorded in pediatrics with ADHD[14]. Inattentive manifestations appear to be associated with language comprehension difficulties, as children do not apparently listen and do not follow teacher's orders[15].

1.4. Phonological processing

Phonological processing (PP) refers to phonological information that we receive through hearing, which is directly related to the development of language (oral and written) as a system of alphabetic writing. PP includes Phonological Awareness (PA), Lexical Access (LA) and Working Memory (WM)[16, 17].

We can define the phonological awareness as an ability to manipulate the noise words structure from a sound replacement to the smaller units' segmentation. The PA is an essential factor in the development of reading and writing[18]. The lexical awareness (LA) can be defined as part of the speed of information processing. Studies suggested that the LA is accompanied by reading, especially in comprehension, decoding skills, and fluency[19]. Working memory (WM) refers to the ability to retain and manipulate information temporally during performance of cognitive tasks such as comprehension, reasoning, and learning[20].

Learning difficulties present in ADHD implicate potential alterations in phonological processing, including problems in phonological organization of speech (alteration in sequential as well as temporal organization of phonemes); decoding, featured by omissions and substitutions of words and phonemes; in coding, including changes in sequential and temporal organization of grapheme; development of writing by changing the logical order of sentences and unorganized textual production[21].

To conduct tasks of phonological awareness, it needs time and requires higher attention and concentration. Children with ADHD may have problems in these tasks as they have inattentional and hyperactivity, affecting the retention information. Studies reported that ADHD child has problems in phonological awareness, specifically in phonemes. This is because of the sequential disorganization and time of the phonemes required to complete the planned activity, leading to reading impairment[22].

1.5. Psychometric Evaluation and ADHD

There is proof that children with ADHD show lower intelligence scores in comparison with the average intelligence of ADHD free ones[23]. Studies had shown that negative correlations exist between ADHD and intelligence[24]. At the same line, researchers found that impulsivity is inversely linked to intelligence and positively related to academic failure[25-27]. Although ADHD individuals score lower than controls on psychometric evaluation tests, this might not be the main etiology of their impairments in academic performance[28].

Previously, studies recorded that ADHD has high liability to be found in terms of developmental delay at the level of mild intellectual disability[29]. In addition, it was recorded that in psychometric evaluation, ADHD children tend to have about nine-points lower than children without the diagnosis[23].

Despite that, recent studies had suggested that ADHD could be considered as a reliable diagnosis in children with high psychometric evaluation. In addition, it was recorded that, the criteria of ADHD in children with high psychometric evaluation mirror those between children with average psychometric evaluation.

Persistence ADHD rates were recorded to be the same between high psychometric evaluation and normal psychometric evaluation groups. Additionally, it was demonstrated that functional impairments and psychiatric co-morbidities continued with time in both groups of ADHD patients[30].

Although in some studies, researchers found that ADHD children with high psychometric evaluation tended to have better school outcomes in comparison with normal children with normal psychometric evaluation and ADHD children with low psychometric evaluation. ADHD individuals with high psychometric evaluation had higher mean reading scores. In addition, they appear to show somewhat lower rates of grade retention and school dropout.

The functional effect of ADHD in a child with high psychometric evaluation may become more obvious when the child progresses into later grades in school, leading to late diagnosis of this ADHD subgroup[31]. The better cognitive ability of ADHD subjects with high psychometric evaluation tends to mask deficits accompanied by ADHD, so they may go undiagnosed[32].

AIM OF THE STUDY

The aim of this study was to:

- Study the psychometric evaluation and the language profile of ADHD children in comparison with normal peers.
- Specify aspects of language defect in ADHD children.
- Assess phonological awareness in ADHD children.
- Assess rapid automatized naming as apart of phonological processing in ADHD children.

PATIENTS AND METHODS

3.1. Study design

This study was a case-control one done in Beni-Suef University Hospital. During the study, the total number of recorded cases of ADHD were 50, 30 patients registered in psychiatric outpatient clinics and 20 patients registered in phoniatric outpatient clinics.This study included 60 school children of both genders aged between 6 – 10 years, divided into 2 groups:

- Case group: 30 ADHD patients, 18 patients from psychiatric unit and 12 patients from phoniatric unit. Other recorded cases were excluded as they were not at the age group of the study (below 6 or above 10) or they had other comorbidities (autism, mental retardation). Convenient sample was used to recruit ADHD cases from the outpatient clinics.

- Control group: 30 children with normal development. Systematic random sample was used to recruit control group from primary schools.

Children were assessed from November 2018 till July 2020. All parents agreed to undergo the assessment and provided written consent.

Inclusion criteria of case group:

1. Patients should fulfill the interdisciplinary diagnosis of ADHD according to the DSM-5 (Hyperactivity, inattention, and impulsivity).

2. Patients who were not controlled yet by medication.

Inclusion criteria of control group:

1. Normal development and normal academic performance.

2. No family history of ADHD or other language problems (delayed language disease, hearing impairment, autism).

3. Did not fulfill DSM 5 criteria of ADHD or other major psychiatric disorders.

All children included in this study had the same socio-economic status (according to the scoring of scales for measuring family socioeconomic status for health research in Egypt)[33], also Arabic language is the mother tongue language for all children and their parents.

The exclusion criteria of cases or control:

1. Patients with comorbidities (other psychiatric disorders like autism, mental retardation, brain damage motor handicapped (BDMH), hearing impairment).

2. Patients who have learning disabilities other than ADHD (dyslexia, specific language impairment, speech problems like stuttering).

3. Patients who refused to provide written consent.

The study had the approval of the Ethics Committee of Beni-Suef University, protocol no (FMBSUREC/05032019).

3.2. Methods

All children included in this study were subjected to the following:

a) Personal history.

b) Stanford Binet (fifth edition).

c) ADHD Test.

d) REAL Scale (Receptive Expressive Arabic Language scale).

e) Phonological Awareness Assessment.

f) Rapid Automatized Naming assessment.

a) Personal history:

Name, age, sex, residence, complaint, onset, course, family history, prenatal, natal, and postnatal care, history of any operation or trauma, developmental history.

b) Stanford Binet (fifth edition)[34]:

The test was used for psychometric evaluation. It is suitable for children aged 2 years till adult aged 85 and more. It has several subtests which measure verbal and nonverbal skills.

c) ADHD Test[35]:

This test was used to assess the degree of hyperactivity, impulsivity, and inattention in ADHD children. It is composed of two parts (parents' part and teachers' part), each of them has different questions that were answered by parents and teachers to know the behavior of the child at home and school.

Before doing the test, patients should fulfil the DSM 5 criteria of ADHD. Controls did not fulfil these criteria, so they were not assessed by ADHD test.

All ADHD children in this study had ADHD test and psychometric evaluation done by expert psychologist.

d) REAL Scale (Receptive Expressive Arabic Language scale)[36]:

It is a battery of many tests that could be used to assess receptive and expressive language skills in children and its results give a broad idea about the severity of language difficulties. It allows obtaining scores for various components of language which can help while drawing diagnostic conclusions and outlines of intervention.

Real scale is an individually language assessment tool, contains 13 tests that could be used to assess Arabic language skills in children aged 5 years through 12 years, 11 months, each test is a stand-alone assessment having its scaled score, confidence interval, deciles, and quartiles.

REAL Scale subtests have been classified into:

I -Receptive subtests include:

1- Receptive Vocabulary (RV):

To evaluate the child's receptive vocabulary, groups of four pictures are presented and the child is asked to point to the picture of the object, action, adjective, or color named by the examiner.

2- Sentence Comprehension (SC):

To evaluate the child's ability to understand sentences having various grammatical structures. For the child to respond correctly, both semantic and morphosyntactic aspect of comprehension are required.

3- Understanding Oral Instructions (UOI):

To evaluate the child's ability to follow orally presented instructions. The items are of various difficulty to put an extra load on working memory and auditory processing.

4- Verbal Categorization 1: Receptive part (VCR1) and Expressive part (VCE1)

To evaluate the child's ability to understand functional and/or conceptual relationships between words that are presented and named by the examiner, he is asked to choose the two pictures that he thinks are related to each other (for the receptive part) and then he must verbally justify his response (for the expressive part). It also evaluates the child's ability to grasp and understand the semantic relationships between words.

5- Verbal Categorization 2: Receptive part (VCR2) and Expressive part (VCE2)

To assess the child's ability to understand the relationships between words that share a variety of functional and conceptual relationships, sets of four words are presented and the child is asked to mention the two words that he thinks are related to each other (for the expressive part) and then he must verbally justify his response (for expressive part).

6- Comprehending Orally Presented Paragraphs (COPP):

To evaluate the child's ability to understand information presented in spoken paragraphs, he is asked to listen to three age-specific orally presented paragraphs. After each paragraph, the child is asked five questions related to information in this paragraph.

II-Expressive subtests include:

1- Expressive Vocabulary (EV):

To evaluate the child's expressive vocabulary, various pictures are sequentially introduced, and the child is asked to label each of them.

2- Morpho-syntax (MS):

To evaluate the child's knowledge of grammatical rules in a sentence completion task, he is asked to complete an orally presented sentence that is related to the introduced picture stimulus/stimuli.

3- Sentence Repetition (SR):

To evaluate the child's ability to recall and reproduce sentences of varying length and syntactic complexity, he is asked to repeat sentences that are orally presented by the examiner.

The items are of graded difficulty with the aim of putting an extra load on the auditory verbal memory.

4- Forming Sentence 2 (FS2):

The child is shown a series of pictures and is asked to verbally describe each of the introduced pictures using a certain specific word. The introduced words are graded in difficulty.

e) Phonological Awareness Assessment[37]:

This test is suitable for children in the age group 5.5 -8.5. This test consists of 20 questions which assess word, syllable, and sentence awareness (blending, segmenting), phoneme awareness (isolation, substitution, deletion and blending) and rhyming words (recognizing and generation).

f) Rapid Automatized Naming assessment[38]:

The test is apart from Dyslexia Screening Test for Egyptian Children, which is suitable for children in the age group 6.6-10.6 years. It consists of 20 pictures. It assesses the speed by which the child will name this picture.

All children included in this study were examined by REAL scale, phonological awareness test and rapid automatized naming test, done by expert Phoniatricians.

3.3. Statistical analysis:

Analysis of data was performed using SPSS v. 25 (Statistical Package for Social science) for Windows. Description of quantitative variables was in the form of mean, standard deviation (SD). Description of qualitative variables was in the form of numbers (No.) and percent's (%). Data was explored for normality using Kolmogorov test. Chi-squared test was used to compare cases and controls regarding the categorical variables. T-test was used to compare between cases and controls regarding the normally distributed scale variable and Mann-Whitney test for the non-normally distributed data. Parametric Pearson correlation was used to correlate different scale variables. The significance of the results was assessed in the form of *P*-value with statistically non-significance when *P*-value > 0.05 and statistically significance when *P*-value ≤ 0.05.

RESULTS

In this study we assessed ADHD children in phonological processing and several aspects of language profile compared to normal peers.

Table (1) showed that there was no statistically significant difference between cases and controls regarding their age and sex distribution.

Table (2) showed that there was a statistically significant difference between cases and controls regarding their psychometric evaluation.

Figure (1) shows that the ADHD score was 235.5±22.5 among the studied cases, its median was 232.5 with IQR from 232 to 244.

Table 1: Demographic data of the studied groups:

Characteristics	Cases no=30(%)	Controls n=30(%)	*P* values
Sex			
Males	22(73.3)	18(60)	0.273
Females	8(26.7)	12(40)	
Age			0.324
Mean±SD	7.8±1.3	8.2±1.1	

Table 2: Comparison between cases and controls regarding the psychometric evaluation (IQ):

Stanford Binet (fifth edition)	Cases no=30(%)	Controls n=30(%)	*P* values
Mean±SD	77.3±8.3	83.2±8.1	0.007*

* *P*-value is significant at ≤ 0.05.

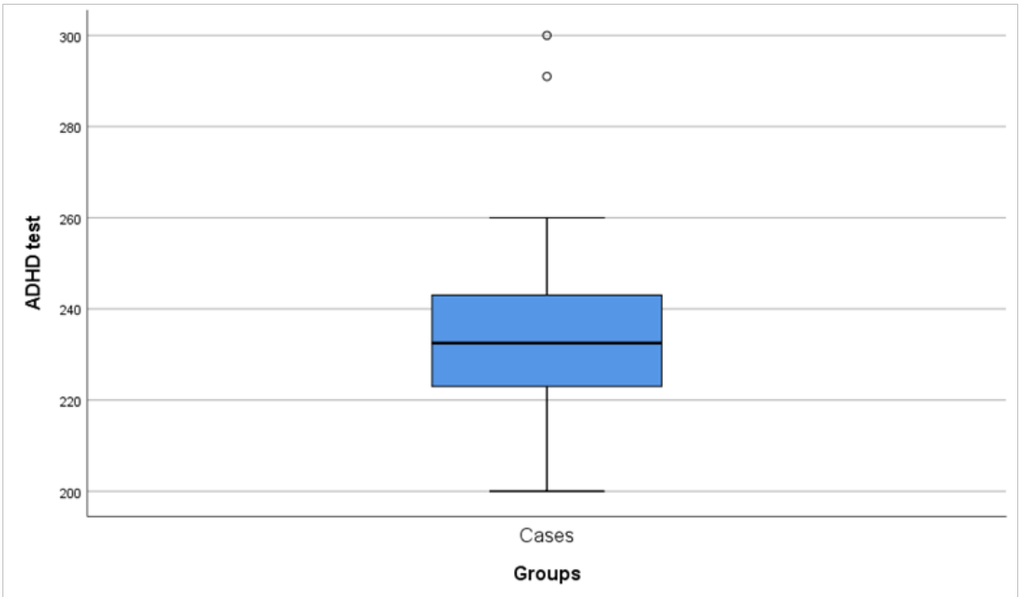

Fig. 1: Boxplot for ADHD test of cases

Table (3) showed that there was a statistically significant increase of the phonological awareness test among controls than cases also the healthy controls had a higher total Real score than the studied cases but there was no statistically significant difference between cases and controls regarding the rapid automatized naming test.

Table (4) showed that there was a statistically significant increase in the receptive vocabulary test among controls than cases also the healthy controls had a higher Sentence comprehension test than the studied cases. But there was no statistically significant difference between cases and controls regarding the Understanding oral instructions test.

Table (5) showed that there was a statistically significant increase regarding the Verbal categorization receptive 1 and 2, Expressive vocabulary, Morphosyntax and the Sentence repetition tests among controls than cases.

Table 3: Comparison between cases and controls regarding the phonological awareness test, rapid automatized naming test and the total REAL scale

Characteristics	Cases no=30(%)	Controls n=30(%)	*P* values
Phonological awareness test Mean±SD	47±25.1	74.9±13.5	<0.001**
Rapid automatized naming Mean±SD	38.1±12.5	34.7±6.2	0.187
Total REAL Scale Mean±SD	74.5±17.3	104.7±10.5	<0.001**

** *P*-value is significant at ≤ 0.001.

Table 4: Comparison between cases and controls regarding the receptive vocabulary, sentence comprehension and understanding oral instructions tests

Characteristics	Cases no=30(%)	Controls n=30(%)	*P* values
Receptive vocabulary Mean±SD	6.3±3.3	8.5±1.2	0.001**
Sentence comprehension Mean±SD	4.6±2.5	7.8±1.3	<0.001**
Understanding oral instructions Mean±SD	6.6±2.9	6.3±1.5	0.702

** *P*-value is significant at ≤ 0.001.

Table 5: Comparison between cases and controls regarding the verbal categorization receptive 1 and 2, expressive vocabulary, morphosyntax and the sentence repetition tests:

Characteristics	Cases no=30(%)	Controls n=30(%)	*P* values
Verbal categorization receptive 1 Mean±SD	4.8±3.4	9.2±1.8	<0.001**
Verbal categorization receptive 2 Mean±SD	5.1±2.8	7.3±1.5	<0.001**
Expressive vocabulary Mean±SD	6.8±3.2	10.1±1.6	<0.001**
Morphosyntax Mean±SD	6±3.9	11.6±2.1	<0.001**
Sentence repetition Mean±SD	5.9±2.7	10.2±1.5	<0.001**

***P*-value is significant at ≤ 0.001.

Table (6) showed that there was a statistically significant increase regarding the Verbal categorization expressive 1 and 2 and Forming sentence 2 tests. But there was no statistically significant difference between cases and controls regarding the Comprehending orally presented paragraphs test.

Table (7) showed that there was no statistically significant difference between males and females regarding different phonological tests done among the studied cases.

Table (8) showed that there was a statistically significant difference between males and females regarding their age, IQ, Receptive vocabulary, Expressive vocabulary and the morpho-syntax.

Despite the significance of higher age among males, females had a significant higher IQ, Receptive vocabulary, Expressive vocabulary, and the morpho-syntax.

Table 6: Comparison between cases and controls regarding the verbal categorization expressive 1 and 2, comprehending orally presented paragraphs, forming sentence 2 tests

Characteristics	Cases no=30(%)	Controls n=30(%)	*P* values
Verbal categorization expressive 1 Mean±SD	5.2±3.2	8.4±1.5	<0.001**
Verbal categorization expressive 2 Mean±SD	5.3±2.5	7.3±1.5	<0.001**
Comprehending orally presented paragraphs Mean±SD	7.9±3.4	9.3±1.6	0.064
Forming sentence 2 Mean±SD	6.7±3.1	8.51.3	0.003*

**P*-value is significant at ≤ 0.05, ***P*-value is significant at ≤ 0.001.

Table 7: Comparison between males and females regarding different tests among the studied cases:

Cases		Mean	SD	*P* value
Age	Males	7.9232	1.45844	0.536
	Females	7.5750	.93197	
IQ	Males	77.68	8.791	0.659
	Females	76.13	7.298	
ADHD test	Males	232.91	22.766	0.290
	Females	242.88	21.243	

Phonological awareness test	Males	49.14	24.548	0.450
	Females	41.13	27.534	
Rapid automatized naming test	Males	35.77	12.490	0.096
	Females	44.38	10.836	
Total REAL Scale	Males	74.95	18.193	0.816
	Females	73.25	15.709	
Receptive vocabulary	Males	6.36	3.303	0.864
	Females	6.13	3.441	
Sentence comprehension	Males	4.36	2.498	0.468
	Females	5.13	2.532	
Understanding oral instructions	Males	6.36	2.985	0.542
	Females	7.13	2.997	
Verbal categorization receptive 1	Males	5.32	3.682	0.202
	Females	3.50	2.204	
Verbal categorization receptive 2	Males	5.09	2.893	0.939
	Females	5.00	2.726	
Expressive vocabulary	Males	6.86	3.270	0.858
	Females	6.63	3.021	
Morphosyntax	Males	6.36	4.204	0.409
	Females	5.00	3.024	
Sentence repetition	Males	6.14	2.731	0.367
	Females	5.13	2.475	
Verbal categorization expressive 1	Males	5.73	3.439	0.169
	Females	3.88	2.232	
Verbal categorization expressive 2	Males	5.45	2.577	0.582
	Females	4.88	2.357	
Comprehending orally presented paragraphs	Males	8.18	3.554	0.576
	Females	7.38	3.114	
Forming sentence 2	Males	7.00	3.132	0.332
	Females	5.75	2.866	

Table 8: Comparison between males and females regarding different language tests among the studied healthy controls.

Controls		Mean	SD	*P* value
Age	Males	8.5722	1.121	0.011*
	Females	7.5167	.897	
IQ	Males	80.56	8.652	0.027*
	Females	87.17	5.508	
Phonological awareness test	Males	76.67	14.617	0.398
	Females	72.33	11.672	
Rapid automatized naming test	Males	34.44	7.114	0.814
	Females	35.00	4.671	
Total REAL Scale	Males	102.50	11.972	0.168
	Females	107.92	6.895	
Receptive vocabulary	Males	8.00	1.085	0.002*
	Females	9.33	.985	

Sentence comprehension	Males	7.67	1.414	0.509
	Females	8.00	1.206	
Understanding oral instructions	Males	6.22	1.801	0.631
	Females	6.50	1.000	
Verbal categorization receptive 1	Males	9.44	2.007	0.379
	Females	8.83	1.528	
Verbal categorization receptive 2	Males	7.56	1.688	0.319
	Females	7.00	1.044	
Expressive vocabulary	Males	9.56	1.688	0.013*
	Females	11.00	1.044	
Morphosyntax	Males	10.67	2.058	0.001**
	Females	13.00	1.206	
Sentence repetition	Males	10.11	1.641	0.697
	Females	10.33	1.303	
Verbal categorization expressive 1	Males	8.28	1.526	0.599
	Females	8.58	1.564	
Verbal categorization expressive 2	Males	7.56	1.688	0.319
	Females	7.00	1.044	
Comprehending orally presented paragraphs	Males	8.89	1.641	0.114
	Females	9.83	1.403	
Forming sentence 2	Males	8.56	1.542	0.910
	Females	8.50	.798	

Table (9) showed that among the cases there was a statistically significant positive linear correlation between the phonological awareness test and age (moderate correlation) and IQ (strong correlation).

There was a statistically significant positive moderate linear correlation between the rapid automatized naming test and the ADHD score.

There was a statistically significant positive moderate linear correlation between the IQ and the Total REAL Scale, Receptive vocabulary, Sentence comprehension, understanding oral instructions, Verbal categorization receptive 1, Verbal categorization receptive 2, Expressive vocabulary, Morpho syntax, Sentence repetition, Verbal categorization expressive 1, Verbal categorization expressive 2, Comprehending orally presented paragraphs and Forming sentence 2.

Table 9: Correlation between patients' age, IQ, and ADHD test (ADHDT) and different language tests

Cases		Age	IQ	ADHD Test
Phonological awareness test	Pearson Correlation (r)	.495**	.650**	-.093
	P-value	.005	<0.001	.624
Rapid automatized naming test	Pearson Correlation (r)	-.359	-.343	.395*
	P-value	.051	.063	.031
Total REAL scale	Pearson Correlation (r)	-.142	.655**	-.314
	P-value	.456	<0.001	.091
Receptive vocabulary	Pearson Correlation (r)	-.090	.578**	-.264
	P-value	.636	.001	.158
Sentence comprehension	Pearson Correlation (r)	-.302	.689**	-.166
	P-value	.105	<0.001	.381

Understanding oral instructions	Pearson Correlation (r)	-.139	.750**	-.116
	P-value	.463	.000	.541
Verbal categorization receptive 1	Pearson Correlation (r)	-.036	.674**	-.337
	P-value	.849	<0.001	.068
Verbal categorization receptive 2	Pearson Correlation (r)	.014	.750**	-.149
	P-value	.942	<0.001	.432
Expressive vocabulary	Pearson Correlation (r)	-.405*	.574**	-.324
	P-value	.026	.001	.080
Morphosyntax	Pearson Correlation (r)	-.170	.580**	-.325
	P-value	.370	.001	.080
Sentence repetition	Pearson Correlation (r)	.066	.697**	-.156
	P-value	.727	<0.001	.412
Verbal categorization expressive 1	Pearson Correlation (r)	-.063	.565**	-.364*
	P-value	.741	.001	.048
Verbal categorization expressive 2	Pearson Correlation (r)	-.085	.660**	-.277
	P-value	.657	.000	.138
Comprehending orally presented paragraphs	Pearson Correlation (r)	.156	.638**	-.071
	P-value	.409	<0.001	.710
Forming sentence 2	Pearson Correlation (r)	.082	.593**	-.351
	P-value	.667	.001	.057

DISCUSSION

Epidemiologic research which uses standardized language test batteries suggested that substantial levels of LI could be expected to co-occur in 45% of children who presented with ADHD manifestations and rates of up to 90% were noticed in research using clinically referred specimens[39].

5.1. Discussion of demographic data:

Among cases of this study, ADHD males represented 73% while females represented 27% (Table 1). The male to female ratio was around 3:1 and this ratio was in agreements with the epidemiological study done by Willcutt, 2012 who found that in childhood, ADHD was very common in males in comparison with females, with a male to female(M/F) ratio of about 3:1[40].

This was also in accordance with Curran *et al.* 2000 who displayed that boys were 2–3 times more commonly affected with ADHD in comparison with girls. In the same line[41], Tahir *et al.* conducted their study on a sample of Turkish children and revealed that, the boys to girls' ratio of ADHD was 3:1[42].

A higher frequency of childhood ADHD in males than females is a reliable finding in ADHD research and is in keeping with the general tendency for males to demonstrate higher levels of externalizing or destructive behavior[43] while females with ADHD demonstrate less destructive behaviors so their issues might be missed by parents and educators[4].

There was no statistically significant difference between males and females regarding all study tests (*P*-value >0.05) (Table 7).

During examination, we found that there was a positive family history of ADHD in 20% of patients in this study. This was in accordance with what researchers found that there was a positive family history of ADHD in 19% of cases versus 0% in controls recommended the genetic component of ADHD. All twin research of ADHD reported that concordance rates were significantly higher between Monozygotic (MZ) pairs (58–82%) than same-

sex Dizygotic (DZ) pairs (31–38%), providing additional proof that ADHD is considerably heritable[44].

5.2. Discussion of comparative data

The results of this study focused on establishing linguistic skills and phonological processing in children with ADHD in comparison with their normal peers.

The first aim was psychometric evaluation of ADHD children in comparison with normal children. ADHD children had lower score than normal children (*P*-value =0.007). Their psychometric evaluation scores were borderline (mean =77.3) (Table 2).

Previous researchers also recorded that children with ADHD had been shown to have lower psychometric evaluation score. For instance, researchers displayed that compared to ADHD free subjects, subjects with ADHD scored an average of nine points lower on most commercial psychometric evaluation tests[23].

During the test ADHD children were restless, failed to pay attention to details, answered questions impulsively, easily distracted, and lost interest in test activity quickly.

The second aim was to assess language skills. Language skills were evaluated totally by REAL Scale test. ADHD children results were lower than normal indicating language problems generally (*P*-value <0.001) (Table 3). This was in agreements with what researchers reported in their studies that most of children with an established ADHD diagnosis had a language disorder also.

In comparison with classically developing children, children with ADHD were at a higher possibility for a lot of markers of LI such as: verbal behavior, delayed onset of 1st words and word combinations, poor performance on standardized tests (vocabulary, syntax, reading fluency and short-term memory), discourse limitations in producing cohesive narratives and pragmatic difficulties accompanied by improper conversational contribution[39].

Through sub tests of REAL Scale, we could establish different aspects of language including receptive and expressive vocabulary, morphosyntax, sentence comprehension, sentence repetition, understanding oral instructions, verbal categorization, and forming sentences and specify the defects, this is **the third aim.**

Regarding vocabulary either receptive or expressive, in this study ADHD children showed lower scores than normal children (*P*-value <0.001) (Tables 4 and 5). This was also what researchers suggested that significant levels of language problems could occur in up to 60% of ADHD cases. These problems may be delayed language acquisition, receptive and expressive vocabulary[45].

In a parallel research, results showed that three quarters of ADHD children were having language problems, many with difficulties in both domains of receptive and expressive vocabulary[46].

In receptive difficulties, ADHD children had problems with following directions, understanding spoken language, and understanding grammatical correlations. In expressive difficulties, the children with ADHD had troubles with sentence formulation and performing word association tasks[47].

The defects in this study were mainly in category names, parts of animals and plants, and academically related words. The relationship between ADHD and vocabulary has been explored by the defect in more complex cognitive skills, such as executive functions.

Regarding comprehension: results of this research showed a significant defect in sentence comprehension (*P*-value <0.001) (Table 4) mainly in long sentences and sentences contain many details, indirect instructions, cause-effect relationships, and contradictory phrases.

In comparing the results of ADHD cases with controls in comprehending orally presented paragraphs (*P*-value=0.064) and understanding oral instructions (*P*-value=0.702) subtests, we did not find any significant difference (Tables 4 and 6).

Despite the statistically insignificant results, ADHD children showed lower scores than normal peers in comprehending orally presented paragraphs. In this study ADHD children showed difficulties in predicting upcoming events and remembering fine details and in-order events.

This corroborated what researchers found that school children with ADHD presented more limited vocabulary as well as more restricted verbal comprehension when compared to their normal peers. Children with ADHD properly understood superficial details but showed deficits in tasks requiring a high degree of effort and control of language and attention.

Therefore, the comprehension of long and complex orders that require memory and grammar lexicon domain (adverbs, pronouns, or prepositions) may require high degree of attentional control and linguistic domain that they cannot present. The reason for difficulties in verbal comprehension for children with ADHD may also be related to information processing speed.

A previous study found that the group of children with ADHD aged between 8 and 11 years understood complex sentences but needed more time to provide accurate responses when compared with the control group[48].

It was shown that they recalled minimal data from paragraphs in comparison with ADHD free ones. In addition, they were less sensitive to the significance of the data they recalled, furthermore, the limited use of conjunctions suggested they had difficulties in explaining relationships between events in stories. They also answered fewer questions[49].

Regarding sentence repetition, ADHD children had lower scores than normal children (*P*-value;0.001)

(Table 5). We found that they had difficulties to repeat complex, compound, detailed, and lengthy sentences.

This was in agreements with previous study where researchers assessed semantic as well as syntactic abilities, between other variables, in eleven children with ADHD, compared to 11 ADHD free ones with an average age of 7 years. They demonstrated that children with ADHD had less performance than normal onesin terms of sentence imitation as well as word articulations.

In addition, children with ADHD often receive lower scores in comparison with normal children on the composite quotients of spoken language (such as picture vocabulary, oral vocabulary, grammatical understanding, grammatical completion, and word discrimination) and speaking (such as oral vocabulary, sentence imitation, grammatical completion, and word articulations)[50].

Children with ADHD seemed to experience difficulties in terms of expressive language whichneed working memory including sentence recall[51].

Regarding morphosyntax, ADHD cases had higher significantly defect compared with normal (*P*-value<0.001) (Table 5). Defects were in derived nouns and adjectives, irregular plurals, passive form, and comparative -superlative form.

This corroborated what researchers said that ADHD children used fewer complex utterances with more morphosyntactic errors than normal. ADHD children produced fewer pauses and fewer retractions[52]. This suggested that they spent minimal time making syntactic and lexical decisions; this might be the actual etiology of amount of morphosyntactic errors as well as decreased syntactic complexity.

Regarding verbal categorization, ADHD children had lower results in comparison with normal peers (*P*-value <0.001) (Tables 5 and 6). The defect was in words which were in the same category, had component- product relationships, synonyms, and antonyms.

Regarding forming sentences, ADHD children showed poorer performance than normal (*P*-value <0.001) (Table 6). They had difficulties in forming complex sentences, compound sentences, contradictory phrases, conditional phrases, and sentences involving comparatives. This corroborated what was found that they had difficulties in tasks requiring the recall or formulation of complex sentences[50].

The fourth aim was to assess phonological awareness. In this study ADHD children scores were lower than normal peers (*P*-value <0.001) (Table 3). The defects were mainly in phoneme and syllable awareness (substitution–blending), and in rhyming words (recognition– generation).

Previous studies also found that the children with ADHD demonstrated lower performance in terms of phonological awareness compared to children with typical development[53]. To perform tasks of phonological awareness it needs time and requires higher attentionsas well as concentration children with ADHD may have problems in these tasks as they have attentional impairment and hyperactivity, affecting the retention information.

Studies reported that ADHD child had problems in phonological awareness, specifically in phonemes. This is because of the sequential disorganization and time of the phonemes required to complete the suggested activity, leading to impaired reading[22].

Finally, **the fifth aim** was about Rapid automatized naming. The test measures the time needed to name pictures. The more the time, the lower the scores. Althoughwe found that there was no significant variation among studied cases and controls (*P*-value =0.187), but ADHD children took more time to name pictures, so they still had lower results than normal (Table 3).

This result was in agreements with what was found in previous study where children with ADHD were impaired in Rapid Automatic Naming[54]. Studies showed that subjects who exhibited attentional failures probably had low performance in naming stimuli, and thus, alterations in reading fluency[55]. Naming speed had been implicated in ADHD[56].

It can be noted that individuals with ADHD need more time to name and access their lexicon. This can be explained by the difficulty in the attentional processes found in ADHD. The researchers recorded that this finding was associated with the lower reaction time, and that these effects might be owing to the requirement for greater effort to keep attention. In terms of the researchers, children with ADHD have higher inattention, which may be a potential cause for the poor performance[57].

5.3. Discussion of correlations

By analyzing this study, we found that there were correlations between some results of the studied cases (Table 9).

Regarding psychometric evaluation (IQ) and REAL Scale test, there was a statistically significant positive moderate linear correlation between them (*P*-value <0.001). The higher the psychometric evaluation score, the better the performance in REAL Scale test and all its sub tests (Table 9). Psychometric evaluation score was found to influence the association between language skills and ADHD symptoms[58].

There was a statistically significant positive linear association among the phonological awareness test and age (moderate correlation) (*P*-value =.005). The older the age, the better performance in the test (Table 9).

This corroborated what authors found that younger individuals had greater difficulties and progression of age influenced the improvement of phonological awareness skills. The same was found to occur with persons who

had ADHD. When they were older, their phonological awareness skills became better[18].

There was a statistically significant positive linear association among phonological awareness test and psychometric evaluation (strong correlation) (*P*-value <0.001). The higher the psychometric evaluation score, the better performance in phonological awareness test (Table 9). Those labeled average to high psychometric evaluation possibly tend to have greater levels of phonological awareness in comparison with those who fall below mean on psychometric evaluation.

Finally, regarding ADHD score and RAN test, there was a statistically significant positive moderate linear correlation between them (*P*-value =.031). The higher the ADHD score, the longer the time children take to name RAN test stimuli (Table 9). Slow naming speed associated with greater attentional problems.Naming speed was a valid predictor of later inattention symptoms severity[59, 60].

CONCLUSION

The current study showed that the results of ADHD children, when compared to their normal peers, were lower in language skills, phonological awareness skills and rapid automatized naming. They had lower psychometric evaluation score than normal.

Regarding aspects of language, they had defects in many skills (receptive and expressive vocabulary, morphosyntax, sentence comprehension, story comprehension, verbal categorization, sentence repetition, and forming sentences).

RECOMMENDATION

Research recommendations:

Early assessment of language skills in ADHD children helps in early detection of their defects and begin language therapy tailored according to their deficits early so results will be better.

Therapeutic recommendations:

Reassessment of language of ADHD children after medical treatment and language therapy to evaluate effect of medication on their results and effect of language therapy to detect any progress.

Follow up recommendations:

Further assessment of ADHD children by other tests to evaluate any other defects.

CONFLICT OF INTEREST

There are no conflicts of interest.

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