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Functional Brain Network Connectivity Changes in Children and Adolescents with Attention- Deficit Hyperactivity Disorder: A Resting-State Brain Functional Magnetic Resonance Imaging Study

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: ADHD is one of the most common psychiatric disorders in children and adolescents. Altered functional connectivity has been associated with ADHD symptoms. This study aimed to investigate abnormal changes in the functional connectivity of resting-state brain networks (RSNs) among children and adolescents with different subtypes of ADHD.

Methods: This study was performed on 50 participants Group A: included 30 children and adolescents with ADHD Group B: included 20 normal typically developing controls. All participants aged between 7 and 16 years. All study patients. All participants underwent a neuropsychological assessment by applying the DSM-5 criteria to them. All study children and adolescents will undergo a R-fMRI examination, including Blood oxygenation level dependent BOLD-MRI and pulsed Arterial spin labeling MRI (PASL-MRI).

Results: According to Conner's Rating scale, there was a significant difference between ADHD subtypes and severity. Children with combined subtype were more likely to have severe degree in both teacher and parent editions of Conner's Rating Scale. On the other hand, children with inattentive subtype had less severe degrees by both teacher and parent edition. There were a statistically significance difference between both genders as regard ADHD severity according to Conner's Rating scale (Teacher and parent editions) (P value = 0.049, 0.028 respectively). Males were significantly affected by moderate and severe type compared to females whose affection were mostly mild and moderate. According to CBCL, most of ADHD children had low competence parameters. There was a statistically significant difference (P value < 0.001) on the type of ADHD and social competence in the studied children, where the lowest parameters were found in children with hyperactive type.

Conclusion: There was a statistically significant difference on the type of ADHD and social competence, where the lowest parameters were found in children with hyperactive type.

Keywords: ADHD; resting-state brain networks; functional connectivity.

1. INTRODUCTION

The hunt for biomarkers (measurable indications of a biological state or condition) in neuropsychiatric illnesses is part of a larger effort. Motivations for pursuing biomarkers may include gaining a deeper understanding of the molecular, anatomical, and physiological mechanisms underlying mental disorders; identifying risk and protective factors; guiding the development of interventions and monitoring their efficacy; and identifying the biological basis of behavioural illness for the general public [1].

For a substantial number of the population, the issue of whether ADHD is "genuine" is not rhetorical. Hence, this last incentive is of special importance for ADHD. Despite decades of research and clinical trials, many people continue to believe that the diagnosis of ADHD is merely an excuse for laziness or lack of discipline, or that it is a scheme by psychiatrists or pharmaceutical companies to make money by "drugging" children and getting them hooked on their products [2].

ADHD is genuine, and it is present when specific diagnostic criteria are met; in the United States, the most prevalent diagnostic criteria are those specified in DSM-5. However, when contemplating whether ADHD is real, people more often mean in the sense of having identifiable biological differences that can be reliably measured and that can serve as a definitive test of whether someone has or does not have the disorder [3].

Over the past two decades, neurobiological research on attention deficit hyperactivity disorder (ADHD) has grown exponentially, revealing key brain characteristics underlying the functional deficits in response inhibition, hyperactivity, and inattention typically observed in people with this disorder. These developments are significant since the estimated worldwide incidence of ADHD in children and adolescents is 3.4% [4].

Magnetic resonance imaging (MRI)-based research has attempted to define unambiguous neurobiological pathways of ADHD subtypes using measurements of cortical functional activity, structural volumes, and, more recently, by examining brain connections and networks [2].

The proposed neurocircuitry-based model of ADHD integrates research on the importance of inter-regional network architecture including frontal, temporal, and parietal areas, suggesting that the default mode network (DMN) and (cingulo-frontal parietal) attention network underlying the ADHD types [2].

This shift in perspective suggests that the clinical symptoms of ADHD may be the consequence of defective network connections, as opposed to identifiable structural or functional defects. Individual variability in connection patterns may also account for the distinct clinical manifestations of each subtype of ADHD [5].

In this investigation, functional magnetic resonance imaging (fMRI) was utilised to determine whether functional brain connectivity is changed in children and adolescents with ADHD and to link any discovered alterations with clinical and demographic data of children and adolescents with ADHD. In addition, we investigated fMRI brain alterations between children and adolescents with ADHD and those without ADHD.

2. METHODS

This case control study was carried out in Neuropsychiatry Department, Psychiatry and Neurology Center and Diagnostic Radiology department in Tanta University over a period of time starting from October 2020 till September 2022.

2.1 Sample Size

This study was performed on convenient sample of 50 participants. They were classified as follow:

- **Group A:** included 30 children and adolescents with ADHD
- **Group B:** included 20 normal healthy children and adolescents free from any psychiatric disorders

2.2 Method of Selection

The selected children & adolescents aged between 7 and 16 years. All study patients met the diagnostic criteria of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) for the inattentive, hyperactive, or combined ADHD subtypes documented by a psychiatrist. Additionally, age and sex matched healthy children and adolescents were added as controls. They were recruited from family member outpatients, friends, or classmates of the study subjects with ADHD, or relatives of employees of our institutions. Controls had no history of ADHD or any other condition and were also examined to rule out ADHD. All participants underwent a neuropsychological assessment by applying the DSM-5 criteria to them. All study children and adolescents will undergo a R-fMRI examination.

Inclusion criteria were patients Aged 7-16 years, children or adolescent must be able to comprehend and perform study related information or tasks.

Child parents have a willingness to complete study procedures and able to provide written informed consent, Drug naïve patients (not receiving pharmacotherapy or non-pharmacotherapy interventions), Exclusion criteria were History of hypoxic-ischemic events, central nervous system infections, children with other psychiatric disorders, namely autism spectrum disorder, schizophrenia, bipolar disorder, major depressive disorder, and alcohol and substance use disorders, un stale serious medical illness. epilepsy, congenital anomalies, cerebsamplerovascular diseases, and autoimmune diseases, Evidence of structural brain injury detected on magnetic resonance imaging, IQ of less than 80.

2.3 Tools and Instruments

All the participants of the study were subjected to:

2.3.1 Clinical assessment

The clinical assessment included neurological examination, and general examination.

1- **Neurological examination:** This involved examination of cranial nerves, motor system coordination, superficial reflexes, deep reflexes, and the sensory system. The neurological examination was performed to exclude cases with neurological illness. All the participants were having no localization.
2- **General examination:** This involved examination the head and neck, the chest and abdomen.

2.3.2 Detailed psychiatric assessment

A detailed psychiatric assessment was done using the following scales:

The Stanford-Binet test 5th edition (Hanoura & Hamid, 2002; Janzen et al., 2004): The Stanford-Binet test that was revised from the original BinetSimon scale is an individually administered test of cognitive abilities and intelligence, designed to assess individuals between 2 and 85 -plus years.

This test is used for diagnosis of developmental or intellectual disabilities in young children. It consists of both verbal and nonverbal subtests and measures five weighted factors which are: knowledge, quantitative reasoning, visual-spatial processing, working memory, and fluid reasoning. Each of the five factors is given a weight and the combined score is often reduced to a ratio known commonly as the intelligence quotient, or IQ.

This score was calculated by dividing the mental age by chronological age, and then multiplying this number by 100. We used Arabic translated and validated version. It is used for exclusion of patients with I.Q below 80.

2.4 Operational Design

Preparatory phase: During this phase the researcher reviewed local & international literature to get knowledge about the study. This helped in selecting and designing study tools.

Pilot study: It was conducted on 3 Children to assess the applicability of tools & feasibility of data collection.

Performing the study: After taking the needed permissions, the researcher went to the head of Neuropsychiatry Department and explained the research and its objectives and asked for his assistance to perform the study:

- Written Consent was obtained.
- The screening tool was read by the researcher after explaining its aim & instructions.

2.5 Statistical Analysis

Statistical analysis was done by SPSS v27 (IBM©, Armonk, NY, USA). Shapiro-Wilks test and histograms were used to evaluate the normality of the distribution of data. Quantitative parametric data were presented as mean and standard deviation (SD) and were analyzed by ANOVA (F) test with post hoc test (Tukey). Quantitative non-parametric data were presented as median and interquartile range (IQR) and were analyzed by Kruskal-Wallis test with Mann Whitney-test to compare each group. Qualitative variables were presented as frequency and percentage (%) and analyzed using the Chi-square test. Pearson correlation was done to estimate the degree of correlation between two quantitative variables. A two tailed P value < 0.05 was considered statistically significant.

3. RESULTS

3.1 Clinical Results

Age, gender, age group, residence, years of education and type of family were insignificantly different between both groups. Family socio-economic status was insignificantly different between both groups. IQ was insignificantly different between both groups Table 1.

Table 1. Demographic data, Family socio-economic status, and IQ assessment of the studied groups according to Stanford–Binet Intelligence Scale of the studied groups

		ADHD group (n=30)	Control group (n=20)	Test of sig.	P value
Age (years)	**Mean ± SD**	9.7 ± 2.58	9.3 ± 2.08	t= 0.57	0.565
	Range	7 - 15	7 – 15		
Gender	**Male**	20 (66.67%)	15 (75%)	*X2* = 2.45	0.753
	Female	10 (33.33%)	5 (25%)		
Age group	**<12 years**	25 (83.33%)	18 (90%)	--	0.687
	>12 years	5 (16.67%)	2 (10%)		
Residence	**Rural**	20 (66.67%)	15 (75%)	*X2* = 0.09	0.752
	Urban	10 (33.33%)	5 (25%)		
Years of education	**Mean ± SD**	3.97 ± 2.4	3.7 ± 1.63	t = 0.43	0.609
	Range	1 - 9	2 – 8		
Type of family	**Extended**	9 (30%)	8 (40%)	*X2* = 0.18	0.669
	Nuclear	21 (70%)	12 (60%)		

	ADHD group (n=30)	Control group (n=20)	*X2*	P value	
Family	**High**	2 (6.67%)	2 (10%)		
socio- economic	**Average**	7 (23.33%)	7 (35%)	1.190	0.755
	Low	12 (40%)	6 (30%)		
status	**Very low**	9 (30%)	5 (25%)		
IQ	**Mean ± SD**	93.7 ± 10.33	95.5 ± 9.99	0.75	0.54

IQ: Intelligence quotient

In the ADHD group, there were 5 (16.67%) patients had hyperactive subtype of ADHD, 11 (36.67%) patients had inattentive subtype of ADHD and 14 (46.67%) patients had combined subtype of ADHD Table 2.

Age was insignificantly different among subtype of ADHD. Gender was significantly different among subtype of ADHD (P value = 0.026) as male children were more affected by hyperactive and combined subtypes while female children were more affected by inattentive type than male children Table 3.

Regarding the distribution of severity of ADHD according to Conner's Rating Scale, by the teacher edition there were 10 (33.33%) patients with mild degree of severity, 15 (50%) patients with moderate degree and 5 (16.67%) patients with severe degree. By the parent edition, there were 6 (20%) patients with mild degree of severity, 16 (53.33%) patients with moderate degree and 8 (26.67%) patients with severe degree.

According to the teacher edition, moderate degree of severity was more prevalent followed by mild then severe degree while in the parent edition moderate degree of severity was more prevalent followed by severe then mild degree Table 4.

Table 2. Distribution of clinical subtypes of ADHD

		ADHD group (n=30)
Subtype	**Hyperactive**	5 (16.67%)
	Inattentive	11 (36.67%)
	Combined	14 (46.67%)

Table 3. Demographic characteristics of each subtype of ADHD

		Subtype			X^2	P value
		Hyperactive (n=5)	**Inattentive (n=11)**	**Combined (n=14)**		
Age groups	**<12 years**	5 (100%)	9 (81.82%)	11 (78.57%)	1.247	0.536
	>12 years	0 (0%)	2 (18.18%)	3 (21.43%)		
Gender	**Male**	4 (80%)	4 (36.36%)	12 (85.71%)	**7.231**	**0.026***
	Female	1 (20%)	7 (63.64%)	2 (14.29%)		

**: significant as P value ≤ 0.05*

Table 4. Distribution of severity of ADHD according to Conner's Rating Scale (teacher and parent edition)

		N=30
Severity of ADHD (Teacher edition)	**Mild**	10 (33.33%)
	Moderate	15 (50%)
	Severe	5 (16.67%)
Severity of ADHD (Parent edition)	**Mild**	6 (20%)
	Moderate	16 (53.33%)
	Severe	8 (26.67%)

According to Conner's Rating scale, there was a significant difference between ADHD subtypes and severity. Children with combined subtype were more likely to have severe degree in both teacher and parent editions of Conner's Rating Scale. On the other hand, children with inattentive subtype had less severe degrees by both teacher and parent edition Table 5.

There were a statistically significance difference between both genders as regard ADHD severity according to Conner's Rating scale (Teacher and parent editions) (P value = 0.049, 0.028 respectively). Males were significantly affected by moderate and severe type compared to females whose affection were mostly mild and moderate Table 6.

There was a statistically significant relation between the severity of ADHD by Conner's rating scale (Teacher and parent editions) and Family socio-economic status (P value= 0.032 and 0.036 respectively), as the lower the social level, the greater the severity of ADHD Table 7.

Table 5. Distribution of severity of ADHD (teacher and parent edition) according to Conner's rating scale in relation to clinical subtypes of ADHD

		Subtype			***X^2***	**P value**
		Hyperactive (n=5)	**Inattentive (n=11)**	**Combined (n=14)**		
Severity of ADHD (Teacher edition)	**Mild**	5 (100%)	4 (36.4%)	1 (7.14%)	**15.10**	**0.004***
	Moderate	0 (0%)	6 (54.5%)	9 (64.3%)		
	Severe	0 (0%)	1 (9.1%)	4 (28.6%)		
Severity of ADHD (Parent edition)	**Mild**	3 (60%)	3 (27.3%)	0 (0%)	**11.12**	**0.025***
	Moderate	1 (20%)	7 (63.6%)	8 (57.14%)		
	Severe	1 (20%)	1 (9.1%)	6 (42.8%)		

**: significant as P value ≤ 0.05*

Table 6. Distribution of severity of ADHD (teacher and parent edition) according to gender

		Gender		***X^2***	**P value**
		Male (n=20)	**Female (n=10)**		
Teacher edition	**Mild**	4 (20%)	6 (60%)	**6.00**	**0.049 ***
	Moderate	11 (55%)	4 (40%)		
	Severe	5 (25%)	0 (0%)		
Parent edition	**Mild**	2 (10%)	4 (40%)	**7.12**	**0.028***
	Moderate	10 (50%)	6 (60%)		
	Severe	8 (40%)	0 (0%)		

**: significant as P value ≤ 0.05*

Table 7. Relationship between severity of ADHD by Conner's rating scale (teacher and parent edition) and Family socio- economic status

Family socio-economic status	**Teacher edition**			***X2***	**P value**
	Mild (n=10)	**Moderate (n=15)**	**Severe (n=5)**		
High	1 (10%)	1 (6.67%)	0 (0%)	**13.77**	**0.032***
Average	6 (60%)	1 (6.67%)	0 (0%)		
Low	2 (20%)	8 (53.33%)	2 (40%)		
Very low	1 (10%)	5 (33.33%)	3 (60%)		
	Parent edition				
	Mild (n=6)	**Moderate (n=16)**	**Severe (n=8)**		
High	1 (16.67%)	1 (6.25%)	0 (0%)	**13.47**	**0.036***
Average	4 (66.67%)	1 (6.25%)	2 (25%)		
Low	1 (16.67%)	9 (56.25%)	2 (25%)		
Very low	0 (0%)	5 (31.25%)	4 (50%)		

**: significant as P value ≤ 0.05*

According to CBCL, most of ADHD children had low competence parameters. There was a statistically significant difference (P value < 0.001) on the type of ADHD and social competence in the studied children, where the lowest parameters were found in children with hyperactive type Table 8.

3.2 Radiological Results

Table 9 illustrated the regions with significant difference in the resting-state functional connectivity, between healthy control subjects and ADHD children as revealed by the quantitative analysis of changes in Region of Homogeneity (ReHo) values of the selected regions of interest that displayed on the automatically generated resting-state brain activity maps (with the threshold was corrected for multiple comparisons at p<0.05).

When comparing the ADHD children to the typically developed healthy control subjects, we detected a significant differences in the resting-state functional connectivity of the resting- state networks including dorsal attention network (DAN) (p<0.001), default mode network (DMN) (p=0.003), auditory network (AN) (p<0.001), sensorimotor (SMN) (p=0.019), executive control network (ECN) (p=0.021), and salience network (SN) (p<0.014). It was observed that the brain regions with highly significant differences were observed in the superior temporal gyrus of the auditory network (AN) (p<0.001), superior parietal gyrus (p<0.001) and occipital lobe (p<0.001) of the dorsal attention network (DAN), thalamus (p=0.027), and superior medial frontal gyrus (p=) of the default mode network (DMN), supplementary motor area of the executive control network (ECN), precentral gyrus (p<0.001) of the sensorimotor (SMN), supramarginal gyrus (p<0.001) of the salience network (SN), as well as caudate and putamen (p<0.001 and p=0.045, respectively) of the basal ganglia network.

4. DISCUSSION

Attention deficit hyperactivity disorder (ADHD) is the most prevalent neurodevelopmental disorder in childhood and is characterized by a more acute pattern of inattention and/or hyperactivity-impulsivity than that observed in individuals with a comparable level of development. The etiology of this disorder is unclear; a genetic component is thought to be involved in 70% of cases, and an environmental component in 30% [6].

The aim of our work was to evaluate whether functional brain connectivity is altered in children and adolescents with ADHD and to correlate any detected changes with clinical and demographic data of children and adolescents with ADHD. And we compared fMRI brain changes in children and adolescents with ADHD to children and adolescents without ADHD.

This study was carried out in Neuropsychiatry Department, Psychiatry and Neurology Center and Diagnostic Radiology department in Tanta University over a period starting from October 2020 till September 2022. It was performed on 50 participants. they were classified as 30 children and adolescents' patients with ADHD and 20 normal healthy children and adolescents free from any psychiatric disorders.

Patients in our study were drug naïve patients (not receiving pharmacotherapy or non-pharmacotherapy interventions), to exclude the effect of medications on psychometric evaluation and fMRI results.

Participants with neuropsychiatric disorders other than ADHD were excluded from both cases and controls. Some patients could not complete fMRI procedure, so we excluded them from the study till our target number (patients' group) 30 patients with ADHD and (control group) 20 normal healthy children and adolescents.

As regards age distribution, the current study revealed that age of the studied children in group 1 (patients' group), ranges from 7 – 15 years in the form of 5/30 (16.67%) child aged more than 12 years and 25 (83.33%) aged less than 12 years and the mean age of the cases was (9.7 ± 2.58)years., while in group 2 (control group) from 7 – 15 years; in the form of 2/20 (10%) child aged more than 12 years and 18 (90%) aged less than 12 years and the mean age of the controls was (9.3 ± 2.08). Differences found were non-significant between groups (P value 0.565).

Our finding agrees with [7] who estimated the prevalence of ADHD is more common among children (6-11 years of age) than among adolescents (ages 12–18) as it is a developmental disorder and may persist through out the life span. Also, because patients in our study were drug naïve patients.

Table 8. Relation between type of ADHD and competence parameters of CBCL in studied children

CBCL subscale		Type of ADHD			F	P value
		Hyperactive (n=5)	Inattentive (n=11)	Combined (n=14)		
Participation in activities	**Mean ±SD**	31.25±7.25	37.23±9.01	35.52±11.4	1.29	0.481
Social competence	**Mean ±SD**	26.81±4.03	38.94±7.21	43.09±9.51	**3.35**	**< 0.001***
School competence	**Mean ±SD**	23.25±3.01	27.50±8.21	32.01±8.25	4.08	0.082

**: significant as P value ≤ 0.05*

Table 9. Brain regions with significantly different resting-state ReHo values between children with ADHD (n=30) and typically developed normal health control subjects (n=20)

Examined brain regions	Laterality	Brodmann area	Talairach coordinates (at peak Z-value)			Cluster size (volume, mm^3)	Z-value peak	P value
			X	Y	Z			
Inferior frontal gyrus	RT	47	37	24	-3	405	3.89	**0.041***
	LT	47	-37	25	-17	972	4.45	**0.035***
Inferior frontal gyrus	RT	44	52	16	11	357	4.53	**<0.001***
Superior frontal gyrus	LT	8	-26	46	38	378	4.65	**<0.001***
Superior frontal gyrus	LT	6	-16	11	65	216	3.97	**<0.001***
Middle frontal gyrus	LT	6	-31	3	50	378	4.63	**<0.001***
Posterior medial frontal gyrus	RT	8	7	28	-12	154	3.45	**0.028***
Posterior medial frontal gyrus	LT	8	-7	31	-10	86	3.32	**0.021***
Lateral prefrontal gyrus	LT	6	-12	65	3	183	3.56	**<0.001***
Superior temporal gyrus	LT	38	-38	-55	23	270	3.34	**<0.001***
Inferior temporal gyrus	RT	20	52	-22	-15	216	3.28	**<0.001***
Superior Parietal gyrus	RT	7	21	-64	52	394	3.98	**0.027***
Inferior Parietal gyrus	RT	40	56	-29	23	495	4.18	**0.038***
Superior occipital gyrus	LT	19	-21	-91	32	266	3.54	**<0.001***
Inferior occipital gyrus	LT	19	28	-70	46	268	3.56	**<0.001***
		18	-40	-88	-2	275	3.24	**<0.001***
ACG	RT	32	6	36	22	540	4.23	0.014*
PCC	LT	23	6	-50	23	648	3.78	**<0.001***
		31	-7	-56	22	457	4.25	**<0.001***
Cuneus	RT	18	9	-76	22	378	4.27	**<0.001***

Examined brain regions	Laterality	Brodmann area	Talairach coordinates (at peak Z-value)			Cluster size (volume, mm^3)	Z-value peak	P value
			X	Y	Z			
Cuneus	LT	18	-12	-74	23	270	4.01	**0.017***
Cuneus	LT	17	-22	-90	2	783	3.32	**<0.001***
Precuneus	LT	7	-23	-73	42	520	4.36	**<0.001***
Lingual gyrus	RT	18	15	-85	-4	270	4.58	**0.039***
Lingual gyrus	LT	17	-9	-91	-6	270	3.96	**<0.001***
Parahippocampal gyrus	LT	38	-30	2	-12	138	3.21	**<0.001***
Caudate	LT	-	-6	8	11	324	3.53	**0.045***
Putamen		-	-20	5	-6	318	3.50	**<0.001***
Thalamus	LT	-	-17	-21	5	106	4.06	**0.027***
Cerebellum (posterior lobe)	RT	-	34	-52	-13	568	4.62	**<0.001***
	LT	-	-13	-53	-17	563	4.43	**<0.001***
Cerebellum (anterior lobe)	RT	-	10	-59	-18	446	4.56	**0.036***
	LT	-	-23	-38	-14	450	4.45	**0.047***
Culmen	RT	-	20	29	16	564	3.89	**0.028***
Pyramis	RT	-	31	-75	-30	564	3.98	**<0.001***
	LT	-	-30	-77	-31	356	3.56	**<0.001***
Supramarginal gyrus	LT	40	-52	-45	27	546	4.77	**<0.001***
Fusiform gyrus	LT	19	-34	-52	-10	256	3.90	**0.019***
Precentral gyrus	LT	4	30	-23	59	289	4.27	**0.029***
Postcentral gyrus (sensorymotor area)	LT	1	-42	-29	59	56	3.36	**<0.001***
		2	-40	-36	58	89	3.05	
		3	-36	-31	57	128	3.45	

**: significant as P value ≤ 0.05*

As regards sex distribution, non-significant differences were found between groups. In (patients' group) male patients were (n = 20, 66 %) and female patients (n = 10, 33%). While in group 2 (control group) male patients were (n = 15, 75 %) and female patients (n = 5, 25%).

This finding agrees with previous studies carried out by [8] they found that male children have 2.5 and 5.6 times respectively greater likelihood of ADHD than female children to be diagnosed with ADHD [9]. Argue that the difference may be due to the lower rates of comorbid disruptive behavior in female and less overt manifestations of inattentive type of ADHD in girls or gender differences obviously are culture dependent.

As regards residence, non-significant differences were found between groups. In (patients' group) urban resident children were (n = 10, 33%) and rural resident children were (n = 20, 66 %). While in group 2 (control group) urban resident children were (n = 5, 25%) and rural resident children were (n = 15, 75%).

This finding is inconsistent with the work of [10] who showed a higher proportion of ADHD among urban resident than rural resident children.

As regards ADHD subtypes, another important finding was that the most observed subtype was combined subtype, which constituted 46.67% of the studied sample followed by inattentive subtype which represent 16.67% and lastly hyperactive/impulsive subtype (36.67%).

This finding is consistent with a study done in Fayoum by [11] and another one done in Menoufia by [12] who reported that combined subtype is the most observed subtype among children with ADHD. This may be due to combining information across informants greatly increased the rate of combined type.

As regards gender distribution among ADHD subtypes, this study showed that there was a statistically significant difference between distribution of ADHD subtypes between boys and girls, as boys were more affected with combined and hyperactive subtype while females were more affected by inattentive subtype (P value = 0.026), it is in accordance with [13] who found that inattentive subtype was significantly more common in the girls than the boys.

As regards severity assessment of ADHD, assessment of severity of ADHD by Conners' Rating scale (parent and teacher edition) revealed that moderate degree of severity is present in most of children followed by marked degree in parent edition and by mild degree in teacher edition.

This is consistent with [14] who found that moderate and sever forms are more common than mild forms. This may be accounted to that parents seek medical advice when the condition is severe.

As regards severity assessment of ADHD subtypes, the present study revealed that there was a significant relationship between ADHD subtypes and severity as those with combined subtype were more likely to have more severe forms of the disease. One the other hand, children with inattentive subtype had less severe degrees.

As regards ADHD severity in relation to gender, in the present study, male children significantly suffer from more severe symptoms of ADHD than female children according to Conner's Rating scale (Teacher and parent editions) (P value = 0.049, 0.028 respectively).

This is matched with [15] who detected that male patients significantly suffer from more severe ADHD symptoms. This could be explained by more occurrence of externalizing problem among male children than female children, girls with ADHD were less impaired than boys on most ratings and that boys with ADHD engaged in more rule-breaking and externalizing behaviors than did girls with ADHD [16].

As regards ADHD patient's and competence parameters of CBCL, according to CBCL, most of ADHD children had low competence parameters. There was a statistically significant difference (P value < 0.001) on the type of ADHD and social competence in the studied children, where the lowest parameters were found in children with hyperactive type.

This finding is in harmony with the work of [17] who found that children with ADHD have elevated problems in many areas, including academic functioning and strained social and family relationships [18]. also had found that ADHD has been associated with impaired social skills of children including social disinhibition and a lack of prosocial behavior.

5. CONCLUSION

It is concluded that functional magnetic resonance imaging (fMRI) was utilized to determine whether functional brain connectivity is changed in children and adolescents with ADHD and to link any discovered alterations with clinical and demographic data of children and adolescents with ADHD.

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

CONSENT

As per international standard or university standard, parental' written consent has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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