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The incidence of dysgraphia in Arabic language in children with attention-deficit hyperactivity disorder

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Abstract

Background: Attention-deficit/hyperactivity disorder (ADHD) is a brain disorder marked by an ongoing pattern of inattention and/or hyperactivity-impulsivity that interferes with functioning or development. Although children with ADHD made much more spelling errors, they had a distinct pattern of letter insertions, replacements, transpositions, and omissions. This mistake type is sometimes referred to as graphemic buffer errors, and it is caused by a lack of attention required for motor planning. The aim of study was to assess the incidence of dysgraphia in Arabic language in children with ADHD for better helping, diagnosis and management of those children.

Results: Ten percent of ADHD children had normal handwriting with no disability, 40% had excellent handwriting with a minimum of disability and 50% of ADHD children showed mild to moderate disability. There were significant differences between ADHD children and control children regarding results of each item on the subtest of handwriting of dysgraphia disability scale (DDS), respecting lines, spacing between words, letter direction, spelling a sentence, and punctuation. Drawing affected in ADHD children. The finger tapping speed was affected in almost ADHD children.

Conclusions: Dysgraphia highly presents in our sample of ADHD children with poor fine motor skills in ADHD children than normal children. ADHD children have illegible handwriting, not respecting lines, insufficient space between and within words, multiple spelling errors, and omissions of letters or words. Graphesthesia and stereognosis are affected more in ADHD children than in control children drawing and finger tapping speed affected in ADHD children.

Keywords: Attention-deficit hyperactivity disorder, Dysgraphia, Dyslexia

Background

ADHD is a disease of the brain defined by a persistent pattern of inattention and/or hyperactivity-impulsivity that impairs normal functioning or child's growth [1].

ADHD symptoms according to the National Institute of Mental Health, 2016: Inattention: characterized by lacking persistence, difficulty-sustaining focus, and being disorganized.

Hyperactivity

Differs in children than in adult; children move about constantly or excessively fidget, taps, or talks while in adults, it may be extreme restlessness.

Impulsivity

Children who are impulsive frequently engage in hurried acts that arise spontaneously; they have a significant potential for harm and an insatiable drive for instant fulfilment or an inability to wait satisfaction. An impulsive person may be overbearing in social situations, interrupt others incessantly, or make significant decisions without contemplating the long-term effects [2].

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The actual work was done at Tanta University, Tanta, Egypt.

Although males are more likely to suffer from ADHD than females, behavioral difficulties can vary across boys and girls. For instance, guys may be more energetic, whereas girls may be more inattentive [3].

ADHD symptoms often begin before the age of 12, and in some children, they are visible as early as 3 years of age. ADHD symptoms might be modest to severe and may last into adulthood. ADHD is diagnosed using the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5) criteria which are $\geq$ 6 inattention symptoms present for $\geq$ 6 months that clearly interfere with function and several symptoms must be present in $\geq$ 2 settings (home, school, work, with friends, etc.). The diagnostic process entails obtaining data from a variety of sources, including schools, caregivers, and parents [4].

Dysgraphia is a specific type of learning disability that impairs one's capacity to express himself through writing. It might manifest as spelling issues, bad penmanship, and difficulty expressing thoughts on paper. Dysgraphia can be a language-related or a non-linguistic condition [5].

Although children with ADHD made much additional errors in punctuation, they had a distinct pattern of letter insertions, replacements, transpositions, and omissions. This mistake type is sometimes referred to as graphemic buffer errors, and it is caused by a lack of attention required for motor planning. Writing impairments shown kinematically as rapid, imprecise, and inefficient written products accompanied by increased axial pen pressure. These findings imply that the spelling mistakes and writing deficiencies observed in children with ADHD, as well as their normal reading abilities, are predominantly the product of non-linguistic abnormalities. Students with ADHD (inattentive, hyperactive, or a combination of the two) frequently struggle with writing and handwriting [6].

The aim of this study was to assess the incidence of dysgraphia in Arabic language in children with ADHD for better helping and management of those children.

Methods

Our case-control study was conducted on 40 children; 20 children was diagnosed in Psychiatric Unit as ADHD and chosen randomly from Phoniatric Unit, Tanta University Hospital, matched with 20 normal children with similar age after approval from Ethical Committee and obtaining informed written consent from guardians of children.

Inclusion criteria were ADHD children. The diagnosis of ADHD was made by a child psychiatrist based on DSM-5 and Conners Comprehensive Behavior Rating Scale [7], aged between $6^1/_2$ and 10 years old with IQ $\geq$ 90.

Exclusion criteria were associated sensory (hearing or visual)-deficit disorders and comorbid psychiatric problems.

Preliminary diagnostic procedures

1. History taking.
2. Vocal tract examination: lip, tongue movement, and palatal mobility.
3. Ear and nose examination.
4. Neuropsychiatric examination.
5. Auditory perceptual assessment of language and speech.

Clinical diagnostic aids

1. Stanford–Binet Intelligence Scales "5th Arabic version" [8].
2. Conners Comprehensive Behavior Rating Scale [7].
3. Complete learning disability battery:

    a. Language test by Preschool Language Scale 4 (PLS4)-modified test [9].
    b. Arabic Dyslexia Assessment Test [10] was applied for the age group (6½–10½ years). The examination consists of 11 elements. These include the rapid name test, bead threading, 1-min reading, postural stability, phonemic segmentation, two-minute spelling, backward digit span, reading nonsensical passages, one-minute writing, verbal fluency, and semantic fluency.
    c. Illinois test of psycholinguistic abilities "Arabic version" (El-Sady S, El-Shoubary A, Abd El-Azziz N, Azzam A: Illinois test of psycholinguistic abilities, unpublished). At the representational level, it contains the following subtests: auditory reception, visual reception, auditory association, visual association, verbal expression, and physical expression. At the autonomic level, grammatic closure, visual closure, auditory sequential memory, and sound mixing each of the 12 subtests generated a raw score. The raw scores were converted to psycholinguistic age scores and scaled scores for interpretation.
    d. Dysgraphia Disability Scale, it enables the clinical assessment of fine and sensory motor function. Motor perception, handwriting pattern, drawing pattern, and speed of finger tapping.

DDS is consisted of 20 points each of them is given a fractional value between 0 and 1.

The total score is as follows: 20–17 = normal, 16.75–13 = good (minimal disability), 12.75–9 = fair (mild to moderate disability), 8.75–5 = disable (severe disability), and 4.75–0 = unable (total disability).

Statistical analysis

The data were analyzed using SPSS version 21 on an IBM personal computer. Quantitative variables were presented as mean and standard deviation (SD) and the two groups were compared by using unpaired Student's *t* test. Qualitative variables were presented as frequency and percentage (%) and were analysed by using the chi-square test. The bivariate *r* correlation coefficient is a parametric test that is used to investigate the correlations between age and total score of DDS in control and ADHD children. The significance threshold was set at *p* less than 0.05.

Results

There was insignificant difference in between ADHD males and females in score of DDS, but there was a statistically significant difference between control males and females in score of DDS (Table 1).

There was an insignificant difference between ADHD children and control children as regard age and proprioceptive function (Table 2).

There was a significant difference between ADHD and control children in the total mean scores of the items of fine motor function (ability to grip, pour a glass of water into another, and buttoning) (*p* value < .001) (Table 3).

There was positive correlation between age and DDS score in control children whereas, the elder the age the better score. Additionally, there was no correlation between age and scores of DDS in ADHD children (Figs. 1 and 2).

Normal handwriting with no disability was more in control children (60%) than in ADHD children (10%). Good handwriting with minimal disability was more in ADHD children (40%) than in control children (30%) while mild to moderate disability was more in ADHD children (50%) than in control children (10%). Dyslexia was present in 12 (60%) of ADHD group but it was present in 2 (10%) in control group. There was a significant difference in presence of dyslexia between ADHD and control groups (Table 4).

There were significant differences between ADHD children and control children regarding results of all items of motor function subtest, handwriting, drawing functions, and finger tapping speed except the ability of contouring around a figure (Table 5).

Table 1 Comparison of DDS score means between genders

Scoring of DDS	Sex		*t* test	
	Male	Female		
	Mean ± SD	Mean ± SD	*t*	*P* value
ADHD	13.750 ± 1.844	12.375 ± 0.433	1.453	0.163
Control	16.000 ± 2.038	19.417 ± 0.516	− 3.994	0.001*

DDS Dysgraphia Disability Scale

Table 2 Comparison of total age and DDS score mean between ADHD and control children

	Group		*t* test	
	ADHD (Mean ± SD)	Control (Mean ± SD)	*t*	*P* value
Age (years)	7.883 ± 1.273	7.800 ± 1.277	0.206	0.838
Scoring of DDS	13.475 ± 1.741	17.025 ± 2.344	− 5.437	< 0.001*

DDS Dysgraphia Disability Scale

Discussion

In our study, 60% (12 cases) of ADHD children was diagnosed as dyslexia. This result matches with Germano et al. [11] study which concluded that 20–40% of children with the inattentive subtype of ADHD have reading disorder (RD), whereas 20–40% of children with reading disorder have ADHD. It has been demonstrated that the relationship between ADHD symptoms and reading is primarily inattentive in nature [12]. Neuropsychological examination of the RD and ADHD comorbid groups reveals impairments in processing speed, verbal working memory, phonological short-term memory, naming speed, and executive functions [13].

In this study 50% of cases of ADHD children showed mild to moderate disability (fair ability) and 40% showed minimal disability in comparison with control children 10% showed mild to moderate disability and 30% showed minimal disability, this matches with Marie [14] study which concluded that 58% children with ADHD had poorer handwriting than the typically developed children. In contrast with Celestino et al. [15] study which showed that ADHD had a negligible effect on writing performance, accounting for less than 6.7% of variance in writing quality. The working memory and sustained attention can account for this effect.

Regarding fine motor function, ADHD children have difficulties in fine motor function in comparison with control children these data are corroborated by Mokobane [16] study which demonstrated that children with ADHD have less developed fine motor skills than typically neurodeveloping children. In addition to Bart et al. [17] study which demonstrated that fine motor difficulties were highly prevalent in children with ADHD and Okuda et al. [18] reported children with ADHD exhibited

Table 3 Comparison between ADHD and control children regarding fine Motor Function and proprioceptive function subtest

	Group		*t* test	
	ADHD (Mean ± SD)	Control (Mean ± SD)	*t*	*P* value
Fine motor function				
Grip	0.625 ± 0.128	0.825 ± 0.164	− 4.292	< 0.001*
Pour a glass of water into other	0.925 ± 0.164	1.000 ± 0.000	− 2.042	0.048*
Putting a coin in a safe box	0.975 ± 0.077	1.000 ± 0.000	− 1.453	0.154
Buttoning	0.900 ± 0.170	1.000 ± 0.000	− 2.629	0.012*
Proprioceptive function subtest				
Pain	1.000 ± 0.000	1.000 ± 0.000	–	–
Light touch	1.000 ± 0.000	1.000 ± 0.000	–	–
Pressure	1.000 ± 0.000	1.000 ± 0.000	–	–
Steriognosis	0.775 ± 0.213	0.850 ± 0.205	− 1.134	0.264
Graphesthesia	0.275 ± 0.291	0.375 ± 0.433	− 0.857	0.397

decreased performance in fine motor skills, sensory and perceptual functions, and overall academic performance when compared to children with normal academic performance due to the increased activity level, impulse control, and poor attention of ADHD children. These obstacles can have a substantial influence on academic success.

Graphesthesia was the only proprioceptive ability that showed to be affected in 80% (16 cases) of the ADHD group, while the other proprioceptive abilities were almost normal in all the cases. This result matches with Alpana et al. [19], study which reported that soft neurological signs like stereognosis, and graphesthesia were seen in more than 20% of ADHD children with specific learning disability (SLD). Proprioreceptive perception is unconscious and mediated by sensory receptors in the muscles and joints. It enables the person to perform accurate movements (even with closed eyes) and to automatically and unconsciously adjust body position. Children with impaired body-movement perception have to concentrate on movements that are performed automatically under normal circumstances. They do not perform movements smoothly or quickly. When compared with the movements of children without ADHD, they appear uncoordinated and clumsy [20].

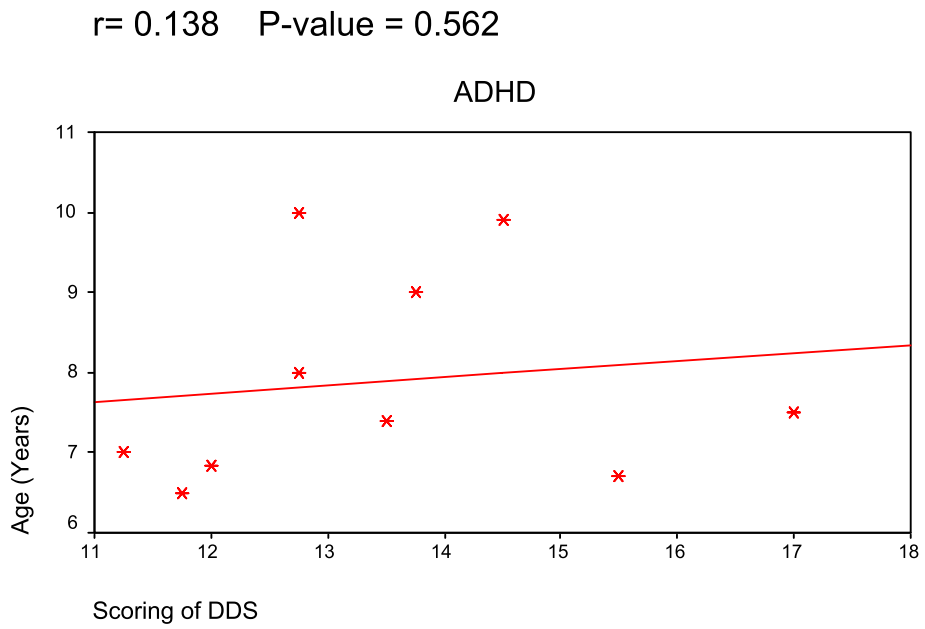

Fig. 1 Correlation between age and total score of DDS in ADHD children

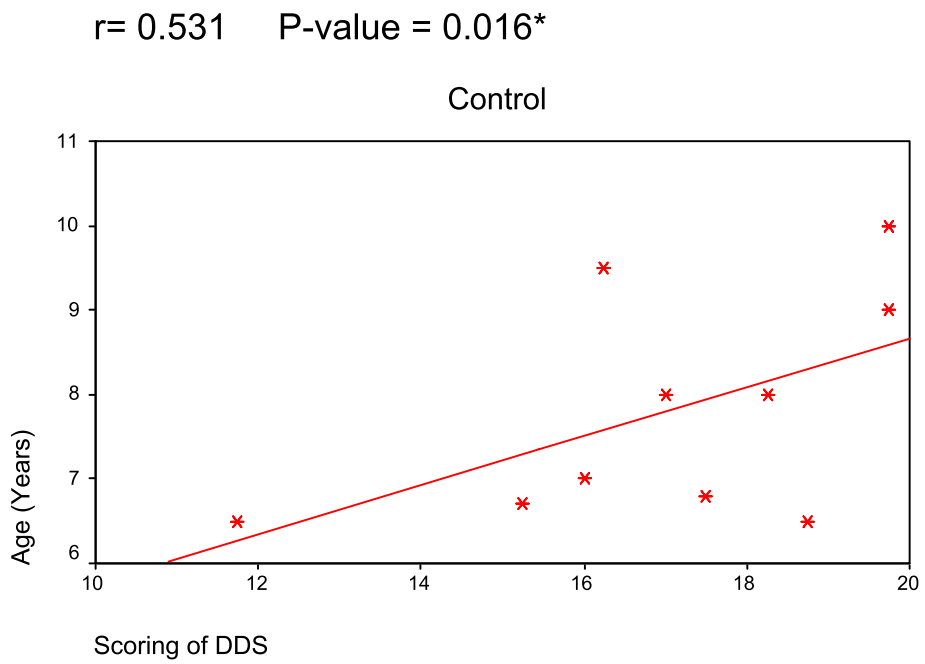

Fig. 2 Correlation between age and total score of DDS in control children

Children with ADHD have difficulties in various executive functions and working memory in particular [21] This may affect their spelling accuracy and handwriting legibility [22].

Children with ADHD produce numerous spelling errors and their writing is difficult to understand. They also make grammatical errors such as insertion of unnecessary letters and omission, substitution, or transposition of letters [23]. This phenomena may be explained by the fact that children with ADHD exhibit more hyperkinetic movements than normally developing youngsters, owing to their hyperactivity and lack of reaction inhibition [24]. They aimed to accomplish the assignment as quickly as possible without regard for the accuracy of the written words or the appropriateness of the pen pressure employed. The majority of spelling mistakes and illegible handwriting can be due to motor programming [25]. Gregg et al. [26] found evidence that ADHD's impulsivity, in particular, contributed to worse writing ability.

Drawing is affected in almost all ADHD children compared with control children this result was like Rosenblum et al. [27] study who stated that there was differences in children with ADHD in drawing task such that findings may not be representing a motor impairment but a cognitive one. In contrast to a study mentioned by The International Dyslexia Association (IDA),

Table 4 Frequency percentage distribution of dysgraphia disability scale ($N = 40$ cases)

Scoring of DDS	Group				Chi-square	
	ADHD		Control			
	N	%	*N*	%	*χ2*	*P* value
Normal handwriting with no disability(20–17)	2	10.00	12	60.00	12.762	0.002*
Good handwriting with minimal disability(16.75–13)	8	40.00	6	30.00		
Mild to moderate disability (fair ability)(12.75–9)	10	50.00	2	10.00		
Severe disability (disable) (8.75–5)	0	0.00	0	0.00		
Total disability(4.75–0)	0	0.00	0	0.00		
Total	20	100.00	20	100.00		
Dyslexia	12	60.00	2	10	10.989	0.001*

Table 5 Comparison between ADHD and control children results regarding scoring of DDS, fine motor function, and proprioceptive function subtest

Motor function subtest	Group		*t* test	
	ADHD (Mean ± SD)	Control (Mean ± SD)	*t*	*P* value
Tying a ribbon	0.400 ± 0.308	0.725 ± 0.268	− 3.563	0.001*
Contouring around a figure	0.800 ± 0.251	0.925 ± 0.231	− 1.638	0.110
Cutting circle	0.700 ± 0.154	0.900 ± 0.170	− 3.899	< 0.001*
Imitation of hand posture	0.500 ± 0.324	0.875 ± 0.172	− 4.567	< 0.001*
Hand writing				
Respecting Lines	0.650 ± 0.205	0.875 ± 0.172	− 3.758	0.001*
Spacing between words	0.675 ± 0.282	0.875 ± 0.172	− 2.707	0.010*
Letter direction	0.725 ± 0.213	0.975 ± 0.077	− 4.935	< 0.001*
Spelling a sentence	0.300 ± 0.224	0.725 ± 0.242	− 5.769	< 0.001*
Punctuation	0.150 ± 0.308	0.775 ± 0.313	− 6.366	< 0.001*
Drawing a man	0.650 ± 0.126	0.750 ± 0.162	− 2.179	0.036*
Finger tapping speed subtest	0.450 ± 0.154	0.600 ± 0.235	− 2.387	0.022*

it considered that drawing is affected due to weak motor performance of the hands.

The finger tapping speed was affected in almost all ADHD children of the sample which is an indication of the motoric-deficit in the hands. This goes with the study that stated that the finger-tapping test (time difference between successive tapings) is a commonly employed quantitative test which gives a general information about deficit in the motor performance of the hand, it evaluates motor function in the upper limbs and the relationship between hand preference and hand skill [28].

Regarding gender, there was insignificant difference between males and females of ADHD children in score of DDS. This is in contrast with Graham and Weintraub [29] who found that girls wrote more legibly than boys; however, this difference was shown to be significant only for the dictation assignment. Perhaps since dictation is a more cognitively demanding task, the discrepancy between the genders became more obvious. On the one hand, studies have shown there was differences in handwriting performance as regarding gender (e.g., Graham et al. [30]; van Waelvelde et al. [31]), whereas in other studies (e.g. Graham, and Weintraub [32]) no gender effect was noted. So, the difference in DDS score between male and females in the ADHD group and control group may be explained by the discrepancies in the results of DDS score between males in females. In addition to that, Cavey [33] has reported that over 75% of whom are male frequently display characteristics that are common to many students with learning disabilities, such as lack of motivation, inability to focus attention, perceptual disorders, or lack of coordination.

Regarding age there was direct correlation between age and total score of DDS in control children, the more age the more good score. On the other hand there was no difference in age and score of DDS in ADHD children, Rosanna et al. [34] study revealing that the frequency of dysgraphia did not decrease with age in children with ADHD, despite the fact that older children receive up to 10 years more writing instruction in school than younger children.

One of the limitations of the study is the small sample size.

Conclusions

Dysgraphia is highly suspected among ADHD children who have dyslexia. Poor fine motor skills are more common in ADHD children compared to normal children. ADHD children have illegible handwriting, inability to keep letters on lines, poor spacing within and between words, multiple spelling errors, and frequent omissions of letters or words. Graphesthesia and stereognosis are affected more in ADHD children than in normal age matched children. Drawing and finger tapping speed are affected in ADHD children.

Abbreviations

ADHD: Attention-deficit/hyperactivity disorder; DDS: Dysgraphia Disability Scale; APA: American Psychiatric Associations; DSM5: Diagnostic and Statistical Manual; IQ: Intelligence quotient; SD: Standard deviation; SLD: Specific learning disability; IDA: International Dyslexia Association.

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Authors' contributions
ASL: data collection, manuscript writing and formatting, manuscript revision. MED: data collection, literature review and manuscript revision. ESR: triggering the idea, data collection, literature review, and manuscript revision. RMS: data collection, literature review and manuscript revision. All authors have read and approved the final manuscript for publication.

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Availability of data and materials
This is available. All data generated or analyzed during this study are included in this published article and its supplementary information files.

Declarations

Ethics approval and consent to participate
This study was approved by the ethics committee of Faculty of Medicine, Tanta University with approval code 32837/01/2019. The guardians of participants provided written informed consent.

Consent for publication
Written informed consent for the publication was obtained from the guardians of participants.

Competing interests
The authors declare that they have no competing interests.

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