

Handwriting in Children with Attention Deficient Hyperactive Disorder analyzing by graphology

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Abstract

Objective Handwriting difficulties are common to children with attention deficient hyperactive disorder (ADHD). The aim of our study was to find distinctive characteristics of the handwriting of children with ADHD by using graphology to analyze physical characteristics and patterns of their handwriting, and to evaluate whether graphological analysis is an effective ADHD diagnostic tool for clinicians.

Method A graphologist analyzed handwriting text from 49 patients, 22/49 previously diagnosed with ADHD, aged 13-18 years, in a randomized, single-blinded study. All study participants wrote a story in Hebrew in 10-12 lines, on a blank paper with a blue pen, during a period of twenty minutes. A licensed graphologist was given the papers, without details, for characterize evaluation. The graphologist suggested a profile of a person with ADHD, and every patient received one point for each ADHD handwriting characteristic, up to 15 points. Patients with 9-15 points were considered to have ADHD, based on their graphology evaluation.

Results The study group included 21 (43%) males and 28 (57%) females, with 15 (71.4%) males and 7 (25%) females diagnosed with ADHD. Overall, the mean score in the ADHD group (9.6, SD=3.49) was significantly higher ($p=0.002$) than in the control group (5.79, SD=4.01).

Conclusion Handwriting in ADHD children and adolescence has specific characteristics, thus graphological analysis could be a useful tool for clinicians in diagnosis of ADHD.

Introduction

Handwriting difficulties, common to both boys and girls with attention deficient hyperactive disorder (ADHD), are associated with lower academic achievement and poor self-esteem [1,2,3]. Motor skill and visual-motor integration were found to correlate positively with legibility; force, timing of agonist and antagonist muscles, and pen pressure are weaker for children with ADHD [2,4].

One way to analyze the handwriting of children with ADHD is by graphology, an ancient technique developed in China to analyze the personality and behavior of the writer through the physical characteristics and patterns of their handwriting [6]. Modern graphology developed at the end of the nineteenth century after Ludwig Klages, a German philosopher and psychologist, created a systematic theory of handwriting analysis [7]. Graphology analysis spread throughout Europe; for example, psychiatrists used graphology in research and diagnosis evaluation. In 1942, graphologist T. S. Lewiston and psychologist J. Zubin developed L-Z scales to objectively evaluate quantitative and qualitative handwriting elements, using statistical evidence to differentiate between handwriting of abnormal and normal personalities [8]. An expert graphologist is able to identify relevant handwriting features in Hebrew, English or other languages, and then analyze how these features interact. The combination of handwriting features and interaction is needed to develop a full and clear interpretation; no single handwriting feature proves anything specific or absolute.

Since the mid–20th century, graphology has been used for a variety of purposes: to find suitable employees, establish authenticity and the state of the author of a signature or a text (e.g., drunk or anxious), and also in courts and during criminal investigations. In medicine, handwriting examinations are recognized diagnostic tools in psychiatry [7] that have been used to diagnose suicide attempts [9] and severe major depressive disorder [10].

The aim of our study was to use graphology to identify distinctive handwriting characteristics in children with ADHD by analyzing the physical characteristics and patterns of their handwriting, to determine whether graphological analysis could be an objective diagnostic tool for clinicians to use in diagnosing ADHD.

Materials And Methods

Participants

The study group consisted of 49 patients, aged 13 to 18 years, who presented during September 2016 - September 2017, at the Pediatric Neurology and Epilepsy Center in Schneider Children's Medical Center of Israel (Petach Tikva, Israel), or Meuhedet Health Services (North District, Israel) clinics. The clinical diagnosis of ADHD was made by a senior pediatric neurologist, basis on the Diagnostic and Statistical Manual of Mental Disorders (4th or 5th edition), published by the American Psychiatric Association (APA) in 1994 and 2013, respectively [11,12]. The non-ADHD group included healthy children and adolescences who had recently presented at the clinics due to mild/moderate headache or simple viral infection.

The hospital's local Ethics Committee approved the single blinded study. Parents or guardians provided signed informed consent for their child prior to enrollment. All study participants wrote a story in Hebrew of 10–12 lines, on a blank paper with a blue pen, during a period of twenty minutes. The papers were graded 1–49, and given without additional information to a licensed graphologist, authorized to provide testimonials identifying false documents through graphological evaluation in the Israel court system.

Graphology tests

The graphologist evaluated all handwriting samples focusing on the following characteristics: margins and text layout, line spacing, word spacing, letter spacing, direction of lines, inclination of handwriting, deviation of handwriting, non-conventional letters, letter width, continuity or flow connection, shape of writing, writing speed, and strength of graphism. The graphologist suggested a profile of a person with ADHD, based on a graphology system of scales. Accordingly, each patient received one point per handwriting characteristic of ADHD, up to 15 points. Patients with 9–15 points were considered to have ADHD, based on their graphology evaluation.

Statistical analysis

Graphology tests scores were compared among groups stratified by sex. Since scores showed a normal distribution, the non-parametric test Mann-Whitney U was used in the data analyses. All tests were two-tailed, and the level of significance was set at $p < 0.05$. The Chi-square test was used to compare categorical data.

The diagnostic accuracy of the graphology tests was examined using receiver operating characteristic (ROC) analysis, which depicts sensitivity by 100%-specificity for every possible cutoff score, with a resulting area under the curve (AUC) ranging from 0.5 (no better than chance) to 1 (perfect diagnostic accuracy). An AUC of 0.8 or higher suggests an instrument can be considered a useful screening tool [13]. Sensitivity, specificity, positive/negative likelihood ratios (LR), and 95% confidence intervals (CIs) were also determined.

Results

The study population included 21 (43%) males and 28 (57%) females, with 15 (71.4%) males and 7 (25%) females diagnosed with ADHD by the graphologist. The mean score in the ADHD group was significantly higher than in the control group (9.61 ± 3.49 vs. 5.79 ± 4.01 , $p = 0.002$, respectfully) (Table 1).

Among females, negative graphology scores, with regard to specificity, were calculated in 80 percent of the non-ADHD patients (95% CIs [59.2, 92.8]), and positive graphology scores in 71.5 percent of ADHD patients (95% CI [35.2, 93.5]).

Among males, specificity of graphology test was calculated in 62.5 percent (95% CI [29.5, 88.1]) and sensitivity in 78.6 percent (95% CI [53.1, 93.6]) of patients. The total sensitivity was 75 percent (95% CI [57.1, 88.1]), and total specificity 76.2 percent (95% CI [55.4, 90.3]) (Table 2).

The AUC of the graphology test was 0.756 (95% CI [0.635, 0.877]), with an LR+ of 3.05 (95% CI [1.54, 6.04]) and LR- of 0.32 (95% CI [0.140, 0.70]) (Fig. 1). In females, the area under the ROC curve was 0.757 (95% CI [0.568, 0.946]), LR+ was 3.57 (95% CI [1.32, 9.65]), and LR- was 0.36 (95% CI [0.11–1.18]). In males, the AUC was 0.705 (95% CI [0.506, 0.905]), LR+ was 2.10 (95% CI [0.82, 5.34]) and LR- was 0.34 (95% CI [0.11, 1.07]).

When test elements were examined separately, for boys ADHD spacing between the lines was abnormal and writing speed was never slow ($p < 0.05$). In females with ADHD, only the direction of lines, never horizontal or ascending, was significant ($p < 0.05$).

Discussion

Handwriting is a complex task requiring the integration of different components such as behavior (can be affected by inattentive and hyperactivity), motor planning, fine motor skills, and visual motor perception [14]. The performance of handwriting in ADHD children is often of poor quality with regard to the above variables.

While this study looked for distinct features in children with ADHD's Hebrew handwriting, the same features are relevant for other languages. We hypothesized that patients with ADHD have typical handwriting characteristics (Fig 1 and Fig 2) and used graphology analysis to characterize those features. ADHD was diagnosed as having nine or more of the following 15 handwriting features: text layout is limited or spread out; no margins in the page or only one margin; the slant of handwriting is never to the right; direction of the lines is never ascending; size of the letters are never normal (3–4 cm); many non-conventional letters; letters are only wide or only narrow; no continuity of writing; writing pressure is always heavy; letters are never in thread shape; speed of writing is never slow; and spacing between the lines, words, or letters is never normal. The study found that writing speed in boys with ADHD was never slow, compared to the control group that had more variability in writing speed. Adi-Japha et al. [15] found that the kinematic manifestations of writing deficits were a fast, inaccurate, and inefficient written product. This could be explained by hyperkinetic movements due to hyperactivity features and lack of response inhibition [16], which leads children with ADHD to complete the task as quickly as possible. Since females with ADHD are reported to have fewer hyperactive/impulsive symptoms and more inattentive symptoms compared to males [17], no significant difference in writing speed was found in females. Other studies [4,18] suggest that children with ADHD have more inappropriate speed of execution and motor difficulties than children without ADHD, but did not distinguish the comorbid learning difficulties from ADHD that can cause lower writing speeds [19].

According to the graphologist examination in females with ADHD, the lines were never ascending. This is very interesting since ascending/descending/ fluctuating lines was showed to be the most prevalent (53.6%) indicator of dysgraphia [20]. In our study, we demonstrated that the total sensitivity of graphology analysis of ADHD was 75 percent, and total specificity 76.2 percent.

The main limitations of the study are working with only one graphologist and a small group of children and adolescences, suggesting the need for a larger scale study with multiple blinded graphologists.

In conclusion, handwriting in ADHD children and adolescence has specific characteristics. Using graphology in medicine is actually the most controversial and disputed branch of handwriting analysis. Probably it has less to do with handwriting itself and more to do with the examination of factors that relate to the motor control. Our study is encouraging in that graphological analysis could be an additional and useful tool for clinicians in their diagnosis of ADHD, worthy of consideration.

Declarations

Ethics approval: The hospital's local Ethics Committee (Rabin Medical. Center Helsinki Committee) approved the single blinded study.

Consent for publications Parents or guardians provided signed informed consent for their child to participate and for publication prior to enrollment.

Availability of data and material The data and materials are in a closed closet in my office.

Conflict of Interest: The authors declare that they have no conflict of interest.

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Biographical statement for each contributing author

Rony Cohen, MD, is a pediatric neurologist at Schneider Children's Medical Center of Israel, who conceived, planned, and conducted the experiments; contributed to the interpretation of the results, and took the lead in writing the manuscript.

Batia Cohen Kroitoru, PhD, is a graphologist at the Institute of Applied Graphology, Schneider Children's Medical Center of Israel and Meitar, Israel, who evaluated the hand-writing samples.

Ayelet Halevy, MD, is a pediatric neurologist at Schneider Children's Medical Center of Israel, who introduced and enrolled patients to the study, gave critical feedback, and helped shape the research, analysis and manuscript.

Sharon Aharoni, MD, is a pediatric neurologist at Schneider Children's Medical Center of Israel, who introduced and enrolled patients to the study, gave critical feedback, and helped shape the research, analysis and manuscript.

Irena Aizenberg, MD, is Pediatrician at Meuhedet Health Services, who introduced and enrolled patients to the study, gave critical feedback, and helped shape the research, analysis and manuscript.

Prof. Avinoam Shuper, MD, was the former Director of the Pediatric Neurology clinic at Schneider Children's Medical Center of Israel, who developed the research questions, supervised the analyses and its interpretation, and contributed to the final manuscript.

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References

1. Shen IH, Lee TY, Chen CL (2012) Handwriting performance and underlying factors in children with attention deficit hyperactivity disorder. *Research in Developmental Disabilities* 33(4): 1301–
2. Lange KW, Tucha L, Walitza S, Gerlach M, Linder M, Tucha, O (2007) Interaction of attention and graphomotor functions in children with attention deficit hyperactivity disorder. *Journal of Neural Transmission Supplementum* 72: 249–
3. Yoshimasu K, Barbaresi WJ, Colligan RC, Killian JM, Voigt RG, Weaver AL, Katusic SK (2011) Written-language disorder among children with and without ADHD in a population-based birth cohort. *Pediatrics* 128(3): e605–e612.
4. Schoemaker MM, Ketelaars CE, van Zonneveld M, Minderaa RB, Mulder T (2005) Deficits in motor control processes involved in production of graphic movements of children with attention-deficit-hyperactivity disorder. *Developmental Medicine and Child Neurology* 47(6): 390–39
5. Tucha O, Lange KW (2004) Handwriting and attention in children and adults with attention deficit hyperactivity disorder. *Motor Control* 8(4): 461–4
6. Seifer M (2008) *The Definitive Book of Handwriting Analysis: The Complete Guide to Interpreting Personalities, Detecting Forgeries, and Revealing Brain Activity Through the Science of Graphology*. New Page Books, NJ, USA
7. Schäfer A (2016) Graphology in German psychiatry (1870-1930). *Hist Psychiatry* 27(3):307-19.
8. Lewinson TS, Zubin J (1942) *Handwriting Analysis; A Series of Scales for Evaluating the Dynamic Aspects of Handwriting*. King's Crown Press, Oxford, England
9. Mouly S, Mahé I, Champion K, Bertin C, Popper P, De Noblet D, Bergmann JF (2007) Graphology for the diagnosis of suicide attempts: a blind proof of principle controlled study. *Int J Clin Pract* 61(3):411-5.
10. Giannini M, Pellegrini P, Gori A, Loscalzo Y (2019) Is Graphology Useful in Assessing Major Depression? *Psychol Rep* 122(2):398-410.
11. American Psychiatric Association (APA)(1994) *DSM-IV: Diagnostic and Statistical Manual of Mental Disorders* 4th edition. APA, Washington, DC, USA.
12. APA (2013) *Diagnostic and Statistical Manual of Mental Disorders: DSM-5 Task Force*, 5th edition, APA, Washington, DC, USA.

13. Holmes WC (1998) A short, psychiatric, case-finding measure for HIV seropositive outpatients: performance characteristics of the 5-item mental health subscale of the SF-20 in a male, seropositive sample. *Medical Care* 36(2): 237–243.
14. Racine MB, Majnemer A, Shevell M, Snider L (2008) Handwriting performance in children with attention deficit hyperactivity disorder (ADHD). *Journal of Child Neurology* 23(4):399–406.
15. Adi-Japha E, Landau YE, Frenkel L, Teicher M, Gross-Tsur V, Shalev RS (2007) ADHD and dysgraphia: underlying mechanisms. *Cortex* 43(6): 700–70
16. Langmaid RA, Papadopoulos N, Johnson BP, Phillips JG, Rinehart NJ (2014) Handwriting in children with ADHD. *Journal of Attention Disorders* 18(6): 504–5
17. Gershon J (2002) A meta-analytic review of gender differences in ADHD. *Journal of Attention Disorders* 5(3): 143–154.
18. Brossard-Racine M, Majnemer A, Shevell M, Snider L, Bélanger SA (2011) Handwriting capacity in children newly diagnosed with attention deficit hyperactivity disorder. *Research in Developmental Disabilities* 32(6): 2927–29
19. Li-Tsang CWP, Li TMH, Lau MSW, Ho CHY, Leung HWH (2018) Handwriting assessment to distinguish comorbid learning difficulties from attention deficit hyperactivity disorder in Chinese adolescents: a case-control study. *International Journal of Methods in Psychiatric Research* 27(4): e1718.
20. Martins MR, Bastos JA, Cecato AT, Araujo Mde L, Magro RR, Alaminos V (2013) Screening for motor dysgraphia in public school. *Journal of Pediatrics (Rio J)* 89(1): 70–7

Tables

Table 1. Mean scores by ADHD status and sex

	DSM	Mean	N	SD	<i>p</i> value Mann-Whitney U
F	Control	4.7500	20	4.05067	0.074
	ADHD	9.0000	7	4.47214	
	Total	5.8519	27	4.49533	
M	Control	8.3750	8	2.61520	0.158
	ADHD	9.9286	14	3.49647	
	Total	9.3636	22	3.23000	
Total	Control	5.7857	28	4.01255	0.002
	ADHD	9.6190	21	3.76133	
	Total	7.4286	49	4.31567	

ADHD, attention-deficit-hyperactive disorder; SD=standard deviation

Table 2. Graphology characteristics predicting ADHD or control group

Gender	Study Group	Graphology	DSM		Total
			Control	ADHD	
Female	Control	Count	16	2	18
		% within graphology	88.9	11.1	100.0
		% within DSM (range)	80.0 (59.2-92.8)	28.6	66.7
	ADHD	Count	4	5	9
		% within graphology	44.4	55.6	100.0
		% within DSM (range)	20.0	71.4 (35.2-93.5)	33.3
	Total	Count	20	7	27
		% within graphology	74.1	25.9	100.0
		% within DSM	100.0	100.0	100.0
Male	Control	Count	5	3	8
		% within graphology	62.5	37.5	100.0
		% within DSM	62.5 (29.5-88.1)	21.4	36.4
	ADHD	Count	3	11	14
		% within graphology	21.4	78.6	100.0
		% within DSM	37.5	78.6 (53.1-93.6)	63.6
	Total	Count	8	14	22
		% within graphology	36.4	63.6	100.0
		% within DSM	100.0	100.0	100.0
Total	Control	Count	21	5	26
		% within graphology	80.8	19.2	100.0
		% within DSM (range)	75.0 (57.1-88.1)	23.8	53.1
	ADHD	Count	7	16	23
		% within graphology	30.4	69.6	100.0
		% within DSM (range)	25.0	76.2 (55.4-90.3)	46.9
	Total	Count	28	21	49
		% within graphology	57.1	42.9	100.0
		% within DSM	100.0	100.0	100.0

Sensitivity +95% confidence interval. Specificity +95% confidence interval

Figures

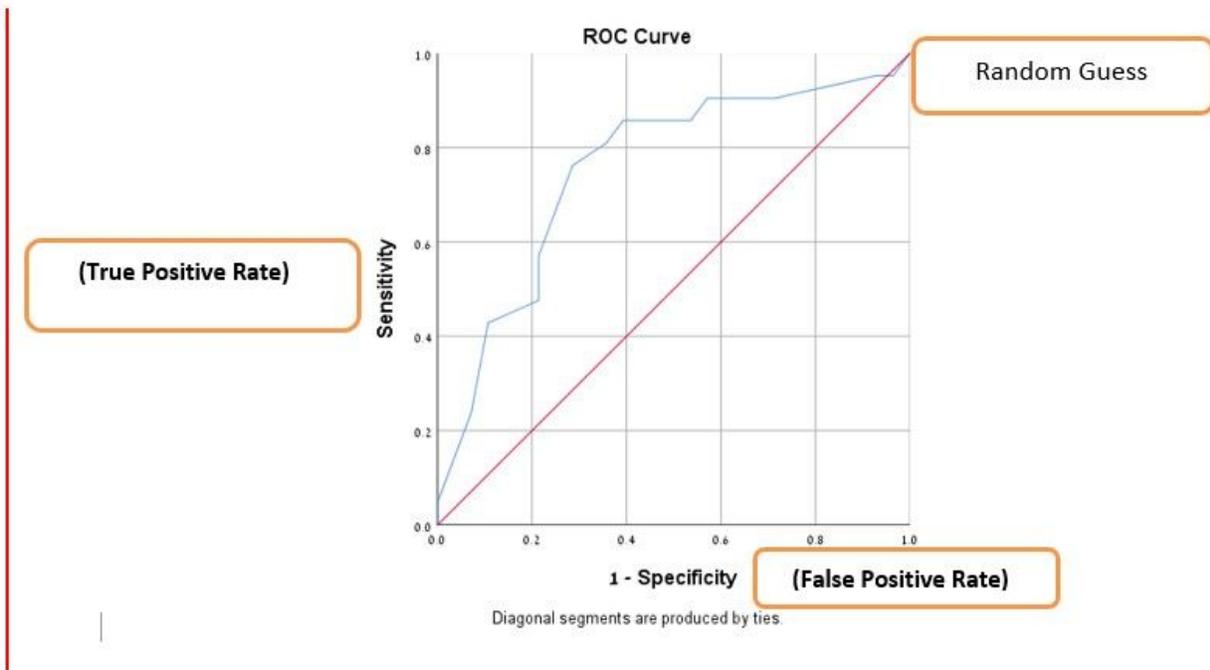


Figure 1

Receiver operating characteristic (ROC) curve for diagnostic ability of ADHD by Graphology

a

שלם קוראים לי. אני מרגיש ברוך
 ומוחלל של קוראים שם אבנים
 חיים. חיים במחנה ביער. כל
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 במוחלל את כל אבנים של
 זה ומוחלל שמוחלל עם השכנה של
 ומוחלל לי אדם של

b

חיים לי ומוחלל שלם ברוך. אדם ומוחלל ספור
 במוחלל. ספור אדם מוחלל, ומוחלל של
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Figure 2

(a) Handwriting in Hebrew (right to left) of a girl without ADHD. (b) Handwriting of a girl in Hebrew (right to left) with ADHD, showing abnormal margins and text layout. Also shows abnormal spacing between letters, words, or lines. There is inclination and deviation in the handwriting. The letters are written unconventionally, with frills and a flow not part of the Hebrew language