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Predictive signs of dysgraphia: graphesthesia as a soft sensory finding in children with writing difficulties in Arabic language

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Abstract

Background Dysgraphia is one of the learning disabilities that require a complex set motor actions. It affects writing skills in the form of poor handwriting, spelling problems, and difficulty in writing thoughts and ideas. Children with learning disabilities often show some soft neurological signs as graphesthesia. The aim of this work is to study graphesthesia as a predictive sign that could be associated with developmental dysgraphia.

Results Graphesthesia test showed significant difference when applied on dysgraphic children compared to children with normal leaning development.

Conclusion Graphesthesia is a soft neurological sign that showed to be affected in Arabic dysgraphic children and could be used as a quick predictive test for dysgraphia before applying the formal graded tests.

Keywords Graphesthesia, Dysgraphia, Learning disabilities, Soft neurological signs

Background

Learning disability is a broad term describing various disorders as dyslexia and dysgraphia that affects certain learning skills as reading and writing [1]. Dysgraphia is one of the learning disabilities that require a complex set motor actions. It affects writing skills in the form of poor handwriting, spelling problems, and difficulty in writing thoughts and ideas [2]. However, it was agreed by authors that having poor handwriting does not mean having dysgraphia.

Deuel [3] defined dysgraphia into three types which are dyslexic dysgraphia, motor dysgraphia, and spatial dysgraphia.

Dyslexic dysgraphia is characterized by illegible hand writing, poor spelling, and reading difficulty. Motor dysgraphia in which the child suffers fine motor deficits affecting their ability in performing fine motoric coordination activities while showing neither motoric weakness nor involuntary movements. Spatial dysgraphia in this type the child is unable to acquire the right directions required to write letters and words accompanied by poor drawing [4].

All types of dysgraphia show common features as irregular shape and size of letters, illegible hand writing, missing letters, and words even in copying tasks. They are unable to respect lines and spaces between letters and words and show insufficient speed [5].

Children with learning disabilities often show soft neurological signs which indicate connection disturbances between the cortical and subcortical regions. Impairments in motor sequencing, motor coordination, and sensory integration of complex movements are examples of the affected soft signs [6].

Graphesthesia, stereognosis, and finger thumb opposition are abilities which when affected are considered of the neurological soft signs that may be detected in children with learning disabilities. A detailed

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evaluation for neurological soft signs may be helpful in the risk prediction, monitoring and follow-up of certain disorders [7].

Recent neuroimaging studies have suggested that mastering writing requires joint learning of reading and writing together to stimulate the development of the graphomotor brain network which is built through identification of letters by visual reading and forming orthographic knowledge [8].

Nicholson and Fawcet in 2011 also suggested that in patients with learning disabilities there is a lack of automaticity in the cerebellar motor circuit due to impaired circuits of procedural learning located in the cerebellum, these neurobiological origins of dysgraphia could justify the lack of concurrent tapping and lining orientation [9].

Functional MRI studies and diffusion imaging studies indicated changes in the gray matter of the left superior frontal region and changes in white matter integrity of the left anterior corona radiator, left superior corona radiator, left middle frontal region and the left superior longitudinal fasciculus. These anatomical changes are correlated with writing difficulties and receiving writing instructions compared to controls [10].

Other changes were also observed in the left cingulate gyrus, a brain region linked to executive functioning and self-regulation, these findings were prominent in a group of dysgraphic children who found difficulties in alphabet writing and word spelling [11].

Graphesthesia is the ability to recognize drawn or traced symbol on the skin by the touch sensation. Its name is derived from the Greek word "graphē" which means writing and the word "aisthēsis" which means perception. Primary sensation should be intact while assessing graphesthesia, as testing graphesthesia depends on cortical sensation [12].

Graphesthesia test is performed usually on the skin of the palm by writing simple letters or single numbers, using an object which provides a clear stimulus, such as pen cap or broken tongue depressor. The patient should understand the test before performing it as with any sensory testing. Verbal response is provided by the patient identifying the drawn figure [13].

Recognizing different shapes drawn on the palm is one of the parietal lobe functions, which relies on working memory and pre-existing cortical representation of these shapes. Fine motor function is predicted by tactile awareness and discrimination during writing skill that requires superficial sensory receptors in the fingers and the primary somatosensory cortex involvement [14].

Testing graphesthesia is a straight forward process that requires no equipment and thus makes it a helpful clinical sign in preliminary diagnosis and prediction of dysgraphia.

Aim of the work

The aim of this work is to study graphesthesia as a predictive sign that could be associated with developmental dysgraphia.

Methods

Prospective case control study was conducted on two groups each formed of 20 children aged from 6.5 to 10.5 years old. The first group is children that had attended the phoniatric unit complaining of learning disability having dysgraphia with or without dyslexia they were chosen randomly after fulfilling the inclusion criteria and was diagnosed with the complete battery of learning disabilities as developmental dysgraphia by the Dysgraphia Disability Scale [4]. Children were collected over 6-month duration. The other group is formed of children with normal learning development as a control group. The children of the dyslexic dysgraphic were given dyslexia training program for 3-month duration, 2 sessions per week before applying the test to ensure phoneme grapheme correspondence ability. An informed consent was obtained from all the caregivers of the participants in this research.

Inclusion criteria

1 Developmental dysgraphia
2 IQ above 90
3 Age from 6 years and 6 months to 10 years and 6 months.

Exclusion criteria

1. Children suffering from any other neurological or sensory problem.
2. IQ below 90

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".

Table 1 Distribution of the studied sample according to age

	Dysgraphic children (*No* = 20)	Controls (*No* = 20)	Test of significance (*p*)
Age (years)			
Mean ± SD	8.4 ± 1.1	8.14 ± 1.27	*p* = 0.413
Median (min.–max.)	8.0 (7.0–10.0)	8.0 (6.6–10.0)	

2. Complete learning disability battery:

    a) Language test by Preschool Language Scale 4 (PLS4)-modified test [15].
    b) Arabic Dyslexia Assessment Test [16] 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, 2-min spelling, backward digit span, reading nonsensical passages, one-minute writing, verbal fluency, and semantic fluency.
    c) Illinois test of psycholinguistic abilities "Arabic version".
    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) [4].

Table 2 Distribution of the studied sample according to each letter

	Dysgraphic children (*No* = 20)	Controls (*No* = 20)	Test of significance (*p*)
Letter /l/			
Mean ± SD	1.15 ± 0.75	3.0 ± 0.0	*p* < 0.001 ***
Median (min.–max.)	1.0 (0.0–2.0)	3.0 (3.0–3.0)	
Letter /ʕ/			
Mean ± SD	0.2 ± 0.41	2.58 ± 0.61	*p* < 0.001 ***
Median (min.–max.)	0.0 (0.0–1.0)	3.0 (1.0–3.0)	
Letter /ħ/			
Mean ± SD	0.25 ± 0.44	2.75 ± 0.44	*p* < 0.001 ***
Median (min.–max.)	0.0 (0.0–1.0)	3.0 (2.0–3.0)	
Letter /w/			
Mean ± SD	1.3 ± 0.73	3.0 ± 0.0	*p* < 0.001 ***
Median (min.–max.)	1.0 (0.0–2.0)	3.0 (3.0–3.0)	
Letter /s/			
Mean ± SD	0.6 ± 0.6	2.95 ± 0.22	*p* < 0.001 ***
Median (min.–max.)	1.0 (0.0–2.0)	3.0 (2.0–3.0)	
Letter /j/			
Mean ± SD	0.0 ± 0.0	1.9 ± 1.02	*p* < 0.001 ***
Median (min.–max.)	0.0 (0.0–0.0)	2.0 (0.0–3.0)	
Letter /m/			
Mean ± SD	0.0 ± 0.0	1.3 ± 1.03	*p* < 0.001 ***
Median (min.–max.)	0.0 (0.0–0.0)	1.0 (0.0–3.0)	
Total score			
Mean ± SD	3.55 ± 2.06	16.95 ± 2.21	*t* = 19.808, *p* < 0.001 ***
Median (min.–max.)	4.0 (0.0–6.0)	(13.0–20.0)	

t independent *t* test

Sd standard deviation

* Significant ($p < 0.05$)

For better concentration, the test should be done in a quiet room. Participants should place their palm of the dominant hand on the table with extended fingers and their eyes should be blindfolded. Then, the examiner should trace a shape on the participant's palm, after clarifying that the distal aspect of the participant's palm was corresponding to the top of the shape drawn. All shapes should be drawn in the same way and direction each time for all patients without lifting the drawing object. Predetermined list composed of 7 Arabic letters was applied in a random order to limit memorizing effect. The 7 chosen letters had no diacritics to allow drawing in one stroke. Each letter should be given 3 trials. Correct identification was counted when the participant expressed verbally the name of the traced letter correctly. Each child was given finally a score out of 21 (3 trials for each letter).

Letters chosen were (/m/, /l/, / j/, /w/, / ħ /, / ʕ /, / s /) because they have no diacritics and can be drawn by a single stroke without lifting the drawing object when written in the Arabic language.

Statistical analysis

Social Sciences (SPSS) version 25 was used for data coding and tabulating. According to distribution of variables using Kolmogorov–Smirnov test, the abnormally distributed quantitative variables were summarized by median as measures of central tendency, range as measures of dispersion while normally distributed quantitative variables were summarized by mean as measures of central tendency, standard deviation as measures of dispersion, the following tests were used:

- Mann–Whitney test was used for comparison of 2 groups of abnormally distributed variables.
- Independent *t* test was used for comparison of 2 groups of normally distributed variables.

Results

Twenty cases of dysgraphic children were chosen randomly from patients attending the phoniatric unit 18 of them were dyslexic dysgraphia and 2 were motoric dysgraphia.

Table 1 illustrates distribution of the studied sample groups according to age as mean age in study sample groups was 8.4±1.1 years ranged from 7.0 to 10.0 years in cases while in mean of age in controls was 8.14±1.27 years ranged from 6.6 to 10.0 years which shows insignificant relation between age and graphesthesia.

Table 2 shows comparison between cases vs controls according to the sound letters (/m/, /l/, / j/, /w/, / ħ /, / ʕ /, / s /) as there is highly statistically significant difference as $p < 0.001^{***}$

The mean of total score in dysgraphic children was significantly decreasing than mean of total score in controls

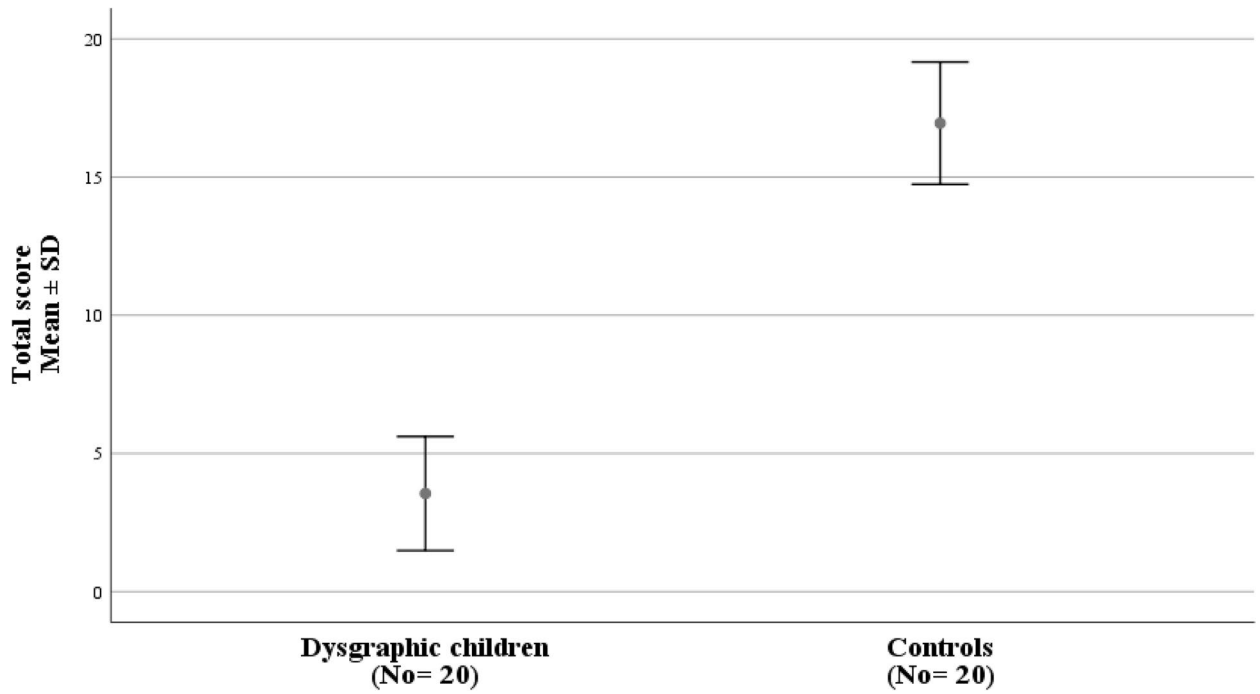

Fig. 1 Comparison between studied sample groups (cases vs controls) according to total score

{(3.55 ± 2.06) vs (16.95 ± 2.21) respectively}, ($t = 19.808$, $p < 0.0001$) as shows in Fig. 1.

The confidence interval of t test 95% (12.03–14.76).

Discussion

In our study, all the children suffering from dysgraphia showed affection regarding graphesthesia. This results matches with Darweesh et al.'s [17], study which showed affection of the graphesthesia subtest while testing proprioceptive functions using Dysgraphia Disability Scale in 70% of the tested dysgraphic children whom were 18 dyslexic, 1 motor, and 1 spatial dysgraphia.

This study showed non-significant difference between age and dysgraphia. However, the chosen age which is from 6.6 months to 10.6 months is considered the golden age for discovering and training different learning disabilities. Overvelde and Hulstijn [18] study stated that stability in handwriting quality occur during the age 8–9 years.

A study done by Lotfy et al. [19] on Arabic dysgraphic ADHD children stated that 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.

Alpana et al.'s [20] study reported that soft neurological signs affection like stereognosis and graphesthesia were seen in more than 20% of ADHD children with specific learning disability.

Most of studies of Arabic graphesthesia were applied on normal adults; for example, the study that was conducted by Alijafen et al. [21] found that female gender, younger age, and higher education are associated with higher scores. On the other hand, there are no enough studies of graphesthesia applied on Arabic-speaking and Arabic-writing children.

Also, most of the studies were done on dysgraphic children generally without specifying the type of dysgraphia or comparing between different types of dysgraphia.

Conclusion and recommendations

Graphesthesia is an affected soft neurological sign in Arabic dysgraphic children and could be used as a quick predictive test for dysgraphia before applying the formal graded tests. We advise more researches to be done with a larger sample size comparing affection of graphesthesia in different types of dysgraphia.

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Study design
Prospective case–control study of 6-month duration was done by applying graphthesia test on the palm of the hands using Arabic letters on children with normal learning development versus dysgraphic children.

Authors' contributions
RS had applied and tested the generated test on the children and had contributed in the scientific writing of the article. GO had contributed in the scientific writing of the article. All authors read and approved the final manuscript.

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Availability of data and materials
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: 35504/5/22. The guardians of participants provided written informed consent.
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Consent for publication
Written informed consent for the publication were obtained from the guardians of participants.

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

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References

1. National Dissemination Center for Learning Disabilities (2011): Learning Disability, NICHCY Disability Fact Sheet 7. January 2011. https://www.parentcenterhub.org/nichcy-gone/#.
2. National Dissemination Center for Learning Disabilities (2012): What is Dysgraphia. May 2020. https://www.understood.org/en/articles/understanding-dysgraphia.
3. Deuel RK (1995) Developmental dysgraphia and motor skill disorders. J Child Neurol 10: 6–8. https://bit.ly/3ivmDuQ
4. El-Deen Hafez NG, Khaled D (2022) Validation of the Dysgraphia Disability Scale (DDS); An assessment tool for writing difficulty. Open J Pediatr Child Health 7(1):001–008
5. Richards R (1998) The writing dilemma: understanding dysgraphia. Riverside,CA: Richards Educational Therapy Center. https://bit.ly/3IzkusT
6. Chan RC, Wang Y, Wang L, Chen EY, Manschreck TC, Li ZJ, Yu X, Gong QY (2009) Neurological soft signs and their relationships to neurocognitive functions: a re-visit with the structural equation modeling design. PLoS One 4(12):e8469. https://doi.org/10.1371/journal.pone.0008469.
7. Sadhu R, Mehta M, Kalra V, Sagar R, Mongia M (2008) Neurological Soft Signs in Indian Children with Specific Developmental Disorders of Scholastic Skills. J Indian Assoc Child Adolesc Ment Health 4:63-66.
8. Nicolson R, Fawcett A (2008) Dyslexia, Learning, and the. Brain. https://doi.org/10.7551/mitpress/9780262140997.001.0001
9. Nicolson RI, Fawcett AJ (2011) Dyslexia, dysgraphia, procedural learning and the cerebellum. Cortex 47(1):117–127
10. Richards TL, Grabowski TJ, Boord P, Yagle K, Askren M, Mestre Z, Robinson P, Welker O, Gulliford D, Nagy W, Berninger V (2015) Contrasting brain patterns of writing-related DTI parameters, fMRI connectivity, and DTI-fMRI connectivity correlations in children with and without dysgraphia or dyslexia. NeuroImage Clin 8:408–421
11. Costa LC, Spencer SV, Hooper SR (2022) Emergent neuroimaging findings for written expression in children: a scoping review. Brain Sci 12(3):406
12. Blumenfeld H (2010) "Neuroanatomy through clinical cases" (2nd, Edition. Sinauer Associates Inc., Sunderland, Massachusetts

13. O'Sullivan SB, Schmitz TJ (2007) "Physical rehabilitation" (5th, Edition. F.A. Davis Company, Philadelphia
14. Brink AO, Jacobs AB (2011) Kinesthetic sensitivity and related measures of hand sensitivity in children with nonproficient handwriting. Pediatr Phys Ther Spring 23(1):88-94. https://doi.org/10.1097/PEP.0b013e318208cc81.
15. Abu-Hasseba A (2011) Standardization, translation and modification of the preschool language scale-4. MD thesis of phoniatrics Cairo. Faculty of medicine, Ain Shams University, Egypt. http://research.asu.edu.eg/handle/12345678/45919.
16. Aboras Y, Abdou R, Kozou H (2008) Development of an Arabic test for assessment of dyslexia in Egyptian children. Bull Alex Fac Med 44:53–662
17. Darweesh ME, Elsady SR, Reifaie NA et al (2020) Dysgraphia: evaluating an Arabic training program for remediation of Egyptian dysgraphic children. Egypt J Otolaryngol 36:43. https://doi.org/10.1186/s43163-020-00041-1
18. Overvelde A, Hulstijn W (2011) Handwriting development in grade 2 and grade 3 primary school children with normal, at risk, or dysgraphic characteristics. Research in Developmental Disabilities 32:540–548. https://doi.org/10.1016/j.ridd.2010.12.027
19. Lotfy AS, Darwish MES, Ramadan ES et al (2021) The incidence of dysgraphia in Arabic language in children with attention-deficit hyperactivity disorder. Egypt J Otolaryngol 37:115. https://doi.org/10.1186/s43163-021-00178-7
20. Somale A, Kondekar S, Rathi S, Iyer N (2016) Neurodevelopmental comorbidity profile in specific learning disorders. Int J Contemp Pediatr 3:355–361
21. Muayqil TA, Alanazy MH, Al-Herbish MJ, Al-Nafisah M, Halawani LM, Al-Bader SS, Al-Yousef LM, Aljafen BN (2018) The role of demographic and symbolic features in clinical Arabic graphesthesia testing. Eur Neurol 80(1–2):19–27. https://doi.org/10.1159/000492183. (Epub 2018 Aug 21 PMID: 30130746)

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