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Neurocognitive performance in children aged 6 to 16 with attention-deficit/hyperactivity disorder without medication

Rendimiento neurocognitivo en niños de 6 a 16 años con trastorno por déficit de atención e hiperactividad sin medicación

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ABSTRACT

Objective: To characterize the neurocognitive profile of children with Attention-Deficit/Hyperactivity Disorder (ADHD) and to identify potential performance differences according to sex. **Methods:** 344 children aged 6–16 years (160 girls and 184 boys) diagnosed with ADHD and examined with the *Evaluación Neuropsicológica Infantil* version 2 (ENI-2) battery were included. **Results:** In the domain of information encoding and memory, children exhibited low performance in both auditory-verbal and visual memory tasks, affecting both encoding and delayed recall, as well as in the complex figure copy task. Girls outperformed boys in verbal tasks and in the simple figure copy. In the domain of language and phonological processing, low performance was observed in syllable and pseudoword writing accuracy, phonemic perceptual skills, silent reading comprehension, word reading accuracy, and metalinguistic skills, with a female advantage in word writing and phonemic abilities. In oral comprehension and production, lower performance was found in silent reading speed and right–left spatial comprehension, whereas higher performance was observed in sentence writing accuracy and oral reading; girls showed superior performance in sentence writing. In verbal fluency and lexical access, performance was low in cancellation tasks and in both phonemic and semantic fluency, with girls showing better performance in the latter. **Conclusion:** Children with ADHD showed consistent patterns of poor cognitive performance and gender differences. Understanding these characteristics could guide more individualized and effective interventions.

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Keywords: attention deficit/hyperactivity disorder; impulsivity; neurocognition; children.

RESUMEN

Objetivo: Caracterizar el perfil neurocognitivo de niños con trastorno por déficit de atención e hiperactividad (TDAH) e identificar posibles diferencias de rendimiento según el sexo. **Métodos:** Se incluyeron 344 niños de entre 6 y 16 años (160 niñas y 184 niños) diagnosticados con TDAH y examinados con la batería de la *Evaluación Neuropsicológica Infantil* versión 2 (ENI-2). **Resultados:** En el dominio de codificación de la información y memoria, se observó bajo desempeño en memoria auditivo-verbal y visual, tanto en la codificación como en la evocación diferida, así como en la copia de figura compleja; las niñas superaron a los niños en tareas verbales y en la copia de figura simple. En lenguaje y procesamiento fonológico, se registró bajo rendimiento en precisión de escritura de sílabas y pseudopalabras, habilidades perceptuales fonémicas, comprensión de lectura silenciosa, precisión de lectura de palabras y habilidades metalingüísticas, con ventaja femenina en escritura de palabras y en habilidades fonémicas. En comprensión y producción oral, se evidenció menor rendimiento en velocidad de lectura silenciosa y en comprensión espacial derecha/izquierda, y mejor ejecución en precisión de escritura de oraciones y en lectura en voz alta; las niñas destacaron en la escritura de oraciones. En fluidez verbal y acceso léxico, el desempeño fue bajo en cancelación y en fluidez fonémica y semántica, con mejor rendimiento femenino en esta última. **Conclusión:** Los niños con TDAH mostraron patrones consistentes de bajo rendimiento cognitivo y diferencias por sexo. El conocimiento de estas particularidades podría orientar intervenciones más individualizadas y efectivas.

Palabras clave: trastorno por déficit de atención e hiperactividad; impulsividad; neurocognición; niños.

INTRODUCTION

Attention-Deficit/Hyperactivity Disorder (ADHD) is a neurodevelopmental condition characterized by attentional dysfunctions, motor hyperactivity, and behavioral impulsivity. These manifestations have a functional impact on cognitive, emotional, academic, and social domains (1). It is one of the most prevalent neuropsychiatric conditions during childhood and adolescence, with estimated rates ranging between 5.9% and 7.1% in the general population (2). Although it begins in childhood, it may persist in adulthood, with a prevalence of approximately 2.5% (3, 4).

In Peru, an epidemiological study conducted in 2007 estimated a prevalence of 9.5% in children aged 6 to 10 years, with a higher frequency in males (ratio 2:1) (5). More recently, a study conducted in Metropolitan Lima in 2020 reported a higher prevalence of 12.1% in the 6 to 11-year-old group (6).

From an etiological perspective, ADHD is conceived as a multifactorial condition with a complex genetic basis and high heritability (7). Its sex distribution shows a male predominance, with an estimated ratio of 2:1 (8).

Recent studies have documented sex-related symptomatological differences. In boys, the hyperactive-impulsive component predominates, with difficulties in response inhibition and cognitive flexibility, whereas in girls, a more internalized profile is observed, which may be associated with underdiagnosis and a higher risk of emotional comorbidities such as anxiety or depression (9, 10).

From a neurocognitive perspective, alterations have been described in various executive functions, such as working memory (verbal and visuospatial), inhibitory control, sustained attention, and planning, as well as difficulties in reward-related regulation (11). However, these alterations may differ significantly according to sex, making it difficult to establish a uniform pattern of cognitive impairment (12). Taken together, the clinical and neurocognitive heterogeneity observed in

ADHD requires a diagnostic and therapeutic approach tailored to individualized patient profiles.

Therefore, this study aims to characterize the cognitive performance of children diagnosed with ADHD and to determine whether there are significant sex-related differences in such performance.

MATERIALS AND METHODS

Design and study subjects

This is a cross-sectional study conducted in 344 patients aged 6 to 16 years (160 girls and 184 boys) from a private medical facility specialized in the care of neuropsychiatric and mental disorders in Lima, Peru. The patient population at this center predominantly comprises individuals from middle- and upper-socioeconomic strata. The inclusion criteria were: A diagnosis of ADHD made by a psychiatrist based on the ICD-10 (13) or DSM-5 (1); completion of the neurocognitive assessment with the *Evaluación Neuropsicológica Infantil* (ENI-2, Child Neuropsychological Assessment) (14, 15) as part of the institution's evaluation protocol between October 2013 and January 2025; regular school attendance; and not having received psychopharmacological treatment for at least two weeks before the assessment. The exclusion criteria were: Severe neurological comorbidity and moderate or severe autism spectrum disorder.

Measures and variables

Variables included sex and age at the time of diagnosis. Neurocognitive functioning was assessed through 34 tasks from the ENI-2 battery, an instrument developed to evaluate neuropsychological functions in pediatric populations (14, 15). It was created by Matute et al. (15) and updated in 2013 to a second version (ENI-2), incorporating psychometric improvements and normative adjustments for Spanish-speaking countries (16). Similarly, there is evidence regarding the applicability of the ENI in Peru (17).

The tasks were administered by a team of psychologists with experience in cognitive child assessment.

The ENI-2 divides functions into cognitive and executive domains, grouping them into 13 and 3 domains, respectively (15). Each domain is composed of subdomains and specific tasks that allow for a detailed assessment of neurocognitive performance, such as sentence reading, phonemic verbal fluency, and letter cancellation, among others (16).

In this study, results are grouped into domains based on previous proposals by different authors (15, 16, 18-22). This classification organizes tasks into broader cognitive domains, facilitating a more integrated and structured interpretation of the obtained neuropsychological profile. The domains and their corresponding tasks are displayed in Table 1. Their conceptualization is presented below:

- *Memory and Information Encoding:* This domain encompasses the processes involved in the acquisition, consolidation, and retrieval of verbal, visual, and tactile information. It includes tasks oriented toward learning, immediate recall, and delayed memory. These functions have been documented as impaired in pediatric populations with ADHD (18).
- *Language and Phonological Processing*: This domain includes functions essential for the development and use of oral language, such as phonological awareness, metalinguistic abilities, auditory discrimination, syntactic processing, and oral expression. These skills are closely related to reading acquisition and academic performance, and they tend to be altered in children with ADHD, particularly in the presence of comorbid language or learning disorders (19, 20).
- *Oral Comprehension and Production*: This domain involves linguistic components related to comprehension, inference, pragmatics, and reading in both oral and silent modalities. Although ADHD is not a language disorder, several studies have highlighted the interaction and possible impairment of verbal functions and executive abilities in this population (21, 22).
- *Verbal Fluency and Lexical Access*: This domain encompasses the ability to efficiently generate words under phonological or semantic criteria and engages executive processes such as verbal working memory, response inhibition, and cognitive shifting. In ADHD, these processes have been described as impaired, negatively affecting discourse fluency, verbal planning, and spontaneous language (11, 23).

Table 1. Domains assessed and ENI-2 tasks administered in children with ADHD.

Domain	Tasks
Memory and information encoding	Figure copy Complex figure copy Verbal encoding memory Visual encoding memory Verbal delayed recall Visual delayed recall Tactile perceptual abilities Visual perceptual abilities Language repetition Language comprehension
Language and phonological processing	Phonemic perceptual abilities Metalinguistic abilities Syllable reading accuracy Word reading accuracy Nonword reading accuracy Sentence reading accuracy Text reading accuracy Sentence reading comprehension Oral reading comprehension Silent reading comprehension Syllable writing accuracy Word writing accuracy Nonword writing accuracy
Comprehension and oral production	Right/left comprehension skills Right/left expression skills Spatial skills for differentiating drawings by angles Oral reading speed Silent reading speed Sentence writing accuracy
Verbal fluency and lexical access	Figure cancellation Letter cancellation Phonemic verbal fluency Semantic verbal fluency (fruits) Semantic verbal fluency (animals)

In the present study, in order to avoid overlap or redundancy in the assessment, certain tasks from the ENI-2 were not administered because other instruments were used to evaluate those same domains. These excluded tasks were: *Constructional Skills*, applied partially, recording only simple and complex figure copying; *Auditory Perception*, applied partially, recording only phonemic perception; *Expressive Language*; *Spatial Skills*, excluding line orientation and coordinate location; *Auditory Attention*; *Conceptual Skills*; and *Cognitive Flexibility*.

Statistical analysis

The descriptive analysis of age and sex was the first step in the data analysis. ENI-2 values were examined through frequency distributions to assess data quality and distribution, confirming that values were adequately recorded. Statistical significance at the 0.05 level was tested for both personal variables: the chi-square test was applied for sex, and the Welch *t*-test for age.

The performance of children with ADHD was analyzed using the Sign Test (Wilcoxon signed-rank test), recommended for the analysis of neuropsychological assessments with ordinal scales, with the ENI-2 50th percentile considered as the normative value. Results include the Hodges–Lehmann estimator, which calculates the *"robust median"* of the test for the studied group (24, 25).

Sex differences in ENI-2 task performance were analyzed using the Brunner–Munzel test, specifically designed for the comparison of two groups with unequal variances, providing greater robustness in detecting differences under this condition (26, 27). The significance level for both tests was set at 0.05.

Statistical analyses were conducted using R and RStudio (versions 4.5.1 and RStudio 2025.05.0+496), with the packages *tidyverse*, *effsize*, *dplyr,* and *scales.* For the *Sign Test*, results are presented as FDR values by domain and overall, controlling for false positives arising from multiple testing and thereby strengthening the validity of findings by increasing the robustness of the analyzed distributions (28-30).

This study was approved by the Institutional Research Ethics Committee of the *Instituto Nacional Cardiovascular "Carlos Alberto Peschiera Carrillo"* of EsSalud, Peru, under Approval Certificate 0030/2025-CIEI.

RESULTS

The proportion of female patients was 46.5% (n = 160), a proportion that did not differ significantly from that of males (p = 0.1957). The mean age was 12.2 years, with a mean of 12.6 years for females and 11.8 years for males. The age difference was statistically significant (p = 0.0106).

The results by domain of performance evaluation using the ENI-2 are described in the following sections:

Memory and information encoding

In this domain, performance on encoding and delayed memory tasks was below the ENI-2 normative value (direction = below 50), with statistically significant differences and corrected values ranging from −8 to −27 points (Table 2). Regarding sex differences, girls outperformed boys in verbal encoding memory and delayed verbal memory tasks. The probability that a girl would outperform a boy was 51.1% (A = 0.428; p = 0.02; FDR = 0.0669) in the first case and 62.2% (A = 0.378; p < 0.0001; FDR = 0.0003) in the latter (Table 3).

In the visuoconstructive task of complex figure copying, children's performance was below the normative value by −7.95 (direction = below 50), a statistically significant result (p < 0.0001). The other visuoconstructive task, simple figure copying, did not show differentiated performance in the sample studied (Table 2). With respect to sex differences, girls performed better than boys in both simple and complex figure copying, although statistical significance was observed only in the former, where the probability that a girl would outperform a boy reached 63% (A = 0.370; p < 0.0001; FDR = 0.0002) (Table 3).

For tactile perceptual skills and language repetition, the study group performed above the normative value, with scores 13 and 6 points higher than the normative value, respectively; both differences, in the direction above 50, were statistically significant (p < 0.0001 and p = 0.003, respectively) (Table 2). No sex differences were observed in the performance of these tasks (Table 3).

In the remaining tasks, such as visual perceptual accuracy and language comprehension, the performance of children with ADHD did not differ from the normative value (Table 2). A similar trend was observed for sex differences: although girls outperformed boys in perceptual skills and boys outperformed girls in language comprehension, the results were not statistically significant (Table 3).

Language and phonological processing

The results obtained in this domain were heterogeneous. In the tasks of nonword writing accuracy, silent reading comprehension, phonemic perceptual skills, word reading accuracy, syllable writing accuracy, and metalinguistic skills, children with ADHD showed performance below the normative value (all p ≤ 0.0055). In contrast, in the tasks involving syllable reading accuracy, text reading accuracy, sentence reading accuracy, word writing accuracy, and oral reading comprehension, performance was above the normative value (all p ≥ 0.0102) (Table 2).

The analysis of sex differences showed significant differences only in word writing accuracy and phonemic perceptual skills. In these tasks, the probability of a girl outperforming a boy was 57.0% (A = 0.430; p = 0.0217; FDR = 0.1496) in the first, and 56.9% (A = 0.431; p = 0.0230; FDR = 0.1496) in the second. Both differences were statistically significant, as shown in Table 3.

Of the remaining 11 tasks, seven favored boys and four favored girls, though none of these differences reached statistical significance (Table 3).

Table 2. Performance on the ENI-2 in children with ADHD aged 6 to 16.

Domains and tasks	Median	IQR	HL	Δ = HL – 50	95% CI Δ	p (Wilcoxon)	FDR dom	FDR global	Sign (>/</=)	Direction
Memory and information encoding										
Verbal delayed recall	16	2-50	23.0	–27.00	[–31, –18.5]	<0.0001	<0.0001	<0.0001	73/234/37	Below 50
Verbal encoding memory	37	9-63	36.0	–14.00	[–18.3, –12]	<0.0001	<0.0001	<0.0001	110/215/19	Below 50
Visual delayed recall	37	9-63	38.0	–12.00	[–14, –10]	<0.0001	<0.0001	<0.0001	117/190/37	Below 50
Visual encoding memory	50	14.2-63	42.0	–8.00	[–11.5, –5.5]	<0.0001	<0.0001	<0.0001	129/171/44	Below 50
Complex figure copy	50	26-63	42.1	–7.95	[–11.5, –5.5]	<0.0001	0.0001	0.0001	123/147/74	Below 50
Tactile perceptual abilities	50	50-63	63.0	13.00	[13, 13]	<0.0001	0.0001	0.0001	132/33/179	Above 50
Language repetition	63	37-75	56.0	6.00	[0, 10.5]	0.0031	0.0044	0.0047	183/109/52	Above 50
Language comprehension	50	37-75	50.0	0.00	[0, 6]	0.2197	0.2746	0.2767	164/126/54	Above 50
Figure copy	63	16-84	50.0	0.00	[–2, 5]	0.5136	0.5706	0.5624	183/126/35	Above 50
Visual perceptual abilities	50	26-75	50.0	0.00	[–3.5, 2]	0.8627	0.8627	0.8627	143/150/51	Above 50
Language and phonological processing										
Nonword writing accuracy	26	9-50	26	–24	[–27, –18.3]	<0.0001	<0.0001	<0.0001	83/246/15	Below 50
Silent reading comprehension	26	16-63	32	–18	[–23.5, –13]	<0.0001	<0.0001	<0.0001	90/224/30	Below 50
Phonemic perceptual abilities	37	9-63	37.6	–12.45	[–17.5, –10.5]	<0.0001	<0.0001	<0.0001	142/174/28	Below 50
Word reading accuracy	50	9-63	39.5	–10.5	[–12.3, –8]	<0.0001	<0.0001	<0.0001	159/161/24	Below 50
Syllable writing accuracy	50	50-50	34	–16	[–18.5, –5.5]	0.0017	0.0024	0.0028	21/34/289	Below 50
Metalinguistic abilities	50	16-75	44.5	–5.5	[–8, 0]	0.0055	0.0071	0.0081	132/153/59	Below 50
Oral reading comprehension	75	50-91	69	19	[13, 27]	<0.0001	<0.0001	<0.0001	236/83/25	Above 50
Word writing accuracy	75	37-84	66	16	[10.5, 25]	<0.0001	<0.0001	<0.0001	210/91/43	Above 50
Syllable reading accuracy	50	50-63	63	13	[13, 13]	<0.0001	<0.0001	<0.0001	161/36/147	Above 50
Sentence reading accuracy	63	37-75	63	13	[6, 13]	<0.0001	<0.0001	<0.0001	250/90/4	Above 50

Median: of the studied group; IQR: interquartile range; HL: Hodges–Lehmann estimator (robust median); Δ = HL – 50: difference between the obtained median and the normative median; 95% CI Δ: confidence interval for Δ; p (Wilcoxon): statistical significance level; FDR dom: p-values adjusted for multiple comparisons to control false positives (Benjamini–Hochberg), within each domain, FDR Global: p-values adjusted for multiple comparisons to control false positives (Benjamini–Hochberg), considering all tests; Sign (>/</=): distribution of the frequency of children scoring above 50 / below 50 / exactly 50; Direction: orientation above or below the normative value of the test result.

Table 2. (*Continuation*).

Domains and tasks	Median	IQR	HL	Δ = HL – 50	95% CI Δ	p (Wilcoxon)	FDR dom	FDR global	Sign (>/</=)	Direction
Text reading accuracy	63	26-75	55.5	5.5	[0, 10.5]	0.0102	0.012	0.0138	209/125/10	Above 50
Sentence reading comprehension	63	26-75	46.5	–3.5	[–5.5, 0.5]	0.4687	0.5078	0.5495	186/141/17	Below 50
Nonword reading accuracy	63	37-63	50	0	[–5.5, 13]	0.5293	0.5293	0.5624	178/88/78	Above 50
Comprehension and oral production										
Sentence writing accuracy	75	37-84	60.5	10.5	[6, 19]	<0.0001	<0.0001	<0.0001	212/98/34	Above 50
Oral reading speed	63	37-84	58.5	8.5	[5, 13]	<0.0001	<0.0001	<0.0001	189/108/47	Above 50
Silent reading speed	37	16-75	44.5	–5.5	[–10.5, –0.45]	0.0060	0.0121	0.0086	130/179/35	Below 50
Right/left spatial comprehension skills	50	16-75	44.5	–5.5	[-10, 0]	0.0127	0.0190	0.0165	125/168/51	Below 50
Right/left spatial expression skills	63	37-75	50.5	0.5	[–4.5, 10.5]	0.2410	0.2892	0.2926	180/95/69	Above 50
Spatial skills for distinguishing drawings by angles	63	26-63	50.0	0.0	[-5.5, 0.5]	0.7186	0.7186	0.7404	198/128/18	Below 50
Verbal fluency and lexical access										
Figure cancellation	26	5-63	31.6	–18.45	[–23.5, –14]	<0.0001	<0.0001	<0.0001	88/217/39	Below 50
Letter cancellation	37	16-63	37.0	–13.00	[–18.45, –8]	<0.0001	<0.0001	<0.0001	95/205/44	Below 50
Semantic verbal fluency for fruits	37	16-63	42.0	–8.00	[–13, –4.5]	<0.0001	<0.0001	<0.0001	114/192/38	Below 50
Phonemic verbal fluency	37	16-75	44.5	–5.50	[–10, –2]	0.0027	0.0034	0.0044	127/173/44	Below 50
Semantic verbal fluency for animals	50	26-75	50.0	0.00	[–4.5, 0.5]	0.5214	0.5214	0.5624	142/164/38	Below 50

Median: of the studied group; IQR: interquartile range; HL: Hodges–Lehmann estimator (robust median); Δ = HL – 50: difference between the obtained median and the normative median; 95% CI Δ: confidence interval for Δ; p (Wilcoxon): statistical significance level; FDR dom: p-values adjusted for multiple comparisons to control false positives (Benjamini–Hochberg), within each domain, FDR Global: p-values adjusted for multiple comparisons to control false positives (Benjamini–Hochberg), considering all tests; Sign (>/</=): distribution of the frequency of children scoring above 50 / below 50 / exactly 50; Direction: orientation above or below the normative value of the test result.

Oral comprehension and production

Of the six tasks assessed in this domain, two were below and two above the normative value. Tasks with performance below the normative value were silent reading speed and right/left spatial comprehension, both showing statistically significant results. Tasks with performance above the normative value were sentence writing accuracy and oral reading speed ($p < 0.0001$). The two remaining tasks in this domain did not differ from the normative value (Table 2).

The analysis of sex-related differences revealed statistically significant results favoring girls in sentence writing accuracy, with a probability of 60.8% of outperforming boys (A = 0.392; p = 0.0004; FDR = 0.0022) (Table 3).

Table 3. Performance on the ENI-2 in children with ADHD aged 6 to 16 years by sex.

Domains and tasks	n_F	n_M	A(M>F)	p_BM	FDR (BH)	Direction
Memory and information encoding						
Figure copy	160	184	0.370	< 0.0001	0.0002	Female > Male
Verbal delayed memory	160	184	0.378	< 0.0001	0.0003	Female > Male
Verbal encoding memory	160	184	0.428	0.0201	0.0669	Female > Male
Visual delayed memory	160	184	0.442	0.0632	0.1512	Female > Male
Visual perceptual skills	160	184	0.445	0.0756	0.1512	Female > Male
Visual encoding memory	160	184	0.457	0.1691	0.2404	Female > Male
Complex figure copy	160	184	0.457	0.1680	0.2404	Female > Male
Language comprehension	160	184	0.538	0.2163	0.2404	Male > Female
Tactile perceptual skills	160	184	0.464	0.1991	0.2404	Female > Male
Language repetition	160	184	0.497	0.9317	0.9317	Female > Male
Language and phonological processing						
Word writing accuracy	160	184	0.430	0.0217	0.1496	Female > Male
Phonemic perceptual skills	160	184	0.431	0.0230	0.1496	Female > Male
Metalinguistic skills	160	184	0.440	0.0517	0.2241	Female > Male
Sentence reading accuracy	160	184	0.528	0.3482	0.9389	Male > Female
Syllable reading accuracy	160	184	0.523	0.4168	0.9389	Male > Female
Sentence reading comprehension	160	184	0.481	0.5349	0.9389	Female > Male
Nonword writing accuracy	160	184	0.516	0.6032	0.9389	Male > Female
Nonword reading accuracy	160	184	0.511	0.7128	0.9389	Male > Female
Silent reading comprehension	160	184	0.490	0.7559	0.9389	Female > Male
Word reading accuracy	160	184	0.492	0.7013	0.9389	Female > Male
Syllable writing accuracy	160	184	0.504	0.8864	0.9389	Male > Female
Text reading accuracy	160	184	0.504	0.8961	0.9389	Male > Female
Oral reading comprehension	160	184	0.502	0.9389	0.9389	Male > Female
Comprehension and oral production						
Sentence writing accuracy	160	184	0.392	0.0004	0.0022	Female > Male
Right–left spatial comprehension skills	160	184	0.539	0.2125	0.6375	Male > Female
Silent reading speed	160	184	0.530	0.3372	0.6745	Male > Female
Spatial skills for differentiating drawings by angles	160	184	0.522	0.4596	0.6894	Male > Female
Right–left spatial expression skills	160	184	0.491	0.7701	0.7892	Female > Male
Oral reading speed	160	184	0.492	0.7892	0.7892	Female > Male
Verbal fluency and lexical access						
Semantic verbal fluency for animals	160	184	0.422	0.0122	0.0386	Female > Male
Semantic verbal fluency for fruits	160	184	0.425	0.0154	0.0386	Female > Male
Phonemic verbal fluency	160	184	0.447	0.0879	0.1465	Female > Male
Figure cancellation	160	184	0.522	0.4788	0.5985	Male > Female
Letter cancellation	160	184	0.490	0.7500	0.7500	Female > Male

n_F: number of females; n_M: number of males; A (M > F): probability that a boy will obtain a higher score than a girl on the test; a value below 0.5 indicates that girls performed better, considering that the total probability is 1; p_BM: statistical significance values from the Brunner–Munzel test; FDR (BH): p-value adjusted using the Benjamini–Hochberg method for multiple comparisons. Direction: indicates the direction of performance superiority on the test.

Verbal fluency and lexical access

Regarding sex differences, semantic fluency for animals and fruits showed statistically significant probabilities of higher performance in girls: 57.8% (A = 0.422; p = 0.0122; FDR = 0.0386) and 57.5% (A = 0.425; p = 0.0154; FDR = 0.0386), respectively. In the remaining tasks, girls outperformed boys in phonemic verbal fluency and letter cancellation, whereas boys outperformed girls in picture cancellation. None of these additional differences was statistically significant (Table 3).

DISCUSSION

This study demonstrates that, within the domain of memory and information encoding, children with ADHD exhibit poor performance in both auditory-verbal and visual memory tasks, encompassing both encoding and delayed recall, which directly impacts the process of academic learning. In addition, a low performance was observed in the task of complex figure copy. By contrast, tactile perceptual skills, language repetition, language comprehension, and simple figure copy remained preserved, supporting the hypothesis that the difficulties in ADHD do not originate in sensory processing but rather in the management and storage of information. The sex differences observed followed patterns already described in the literature: girls outperformed boys in verbal memory and simple figure copy (15).

When analyzing auditory–verbal and visual encoding memory in children with ADHD, poor performance was evident in these tasks, with a statistically significant sex difference favoring girls over boys, but only in the verbal encoding task. These findings are consistent with previous studies linking this poor performance to impairments in sustained attention and working memory (17, 30, 31). With respect to visual encoding memory, three studies have reported similar results, suggesting that the limitations observed are related to deficient attention and low persistent motivation, factors that interfere with the proper encoding of visual stimuli (18, 23, 32).

Regarding delayed auditory–verbal and visual recall, low scores were found in both. In the case of auditory–verbal delayed recall, a significant difference was observed, with boys showing lower performance compared to girls, findings consistent with studies suggesting that this deficit is due to impaired verbal consolidation processes, particularly pronounced in boys (33, 34). In terms of visual delayed recall, similar findings have been reported documenting poor performance in visual tasks, proposing that this type of memory may represent a cognitive endophenotype characteristic of ADHD (35).

As for visuoconstructive tasks, the results of the figure copy indicated that children with ADHD performed above the ENI-2 normative value, highlighting the finding of superior and statistically significant performance in girls compared to boys. These results are consistent with studies describing that basic visuospatial abilities are generally preserved in children with ADHD, but with better performance in girls (33, 34). However, in the complex figure copy task, the significantly lower scores obtained by children with ADHD coincided with findings identifying deficits in visuospatial organization, disordered execution, omission of elements, and impulsive initiation of copying (36).

Adequate or superior performance in tactile perceptual tasks is consistent with studies indicating that such basic functions are usually not impaired in children with ADHD unless comorbid with learning disorders (37). This finding supports the view that ADHD does not primarily involve a sensory processing deficit, but rather difficulties in attentional and executive self-regulation (23). Regarding language repetition, performance above the ENI-2 normative value is consistent with studies showing preservation of the direct phonological route in children with ADHD, given that it is an automatic skill, less dependent on sustained attention or working memory (38, 39).

Finally, in visual perceptual accuracy and language comprehension, no performance differences were observed in the ADHD group. Nevertheless, girls showed higher performance than boys in perceptual skills.

The domain of language and phonological processing showed results suggesting that external language abilities (oral reading) tend to remain relatively intact, whereas internal language (silent reading and comprehension) is significantly impaired due to problems with sustained attention and executive control (40, 41), the influence of deficient internal verbal inhibition (42), and failure to integrate meaning during reading, thereby impairing overall comprehension (43). This latter aspect could be considered a relevant marker of executive language dysfunction in this population.

Children with ADHD showed reduced performance in syllable writing accuracy, nonword writing accuracy, and phonemic perceptual abilities. The results of the first task are consistent with two studies (44, 45) describing specific syllabic-level errors, including syllable omissions, improper segmentation, or accentual and phonological errors. About nonword writing accuracy, two other studies (45, 46) concur with these findings, noting spelling errors (including phonological ones) in children with ADHD during dictation, especially when tasks require maintaining/transforming phonology into orthography (working memory load). Finally, concerning phonemic perceptual abilities, our findings are consistent with one study (47) reporting poor performance in children with ADHD, particularly when comorbid processes are present. Another study highlighted that the phonological errors observed result in writing difficulties, with a higher prevalence of substitution/omission errors indicative of unstable phoneme–grapheme mapping (45).

Other tasks that showed poor language and phonological processing performance included silent reading comprehension, word reading accuracy, and metalinguistic abilities. Regarding the first, the findings coincide with studies that report that children with ADHD present reading comprehension deficits and difficulties in constructing a coherent representation of the text (48), that comprehension decreases with longer texts and sustained attention demands, even in children with ADHD without language disorders (49), and with reports of reading comprehension problems that are associated with working memory and sustained attention deficits (21). Regarding word reading accuracy, previous studies have documented more frequent errors in orthographic recognition/letter reading and poorer word dictation in children with ADHD compared to controls, suggesting impaired accuracy in certain contexts/samples (50). Finally, deficits in this area are linked to poor executive control (22), and greater metalinguistic vulnerability in children is associated with impulsivity and lower capacity for verbal self-regulation.

It is noteworthy that in tasks assessing oral reading comprehension, syllable reading accuracy, sentence reading accuracy, text reading accuracy, and word writing accuracy, children with ADHD achieved significantly higher scores than the normative value. In relation to these findings, prior studies have reported preserved performance, contrary to our results, although these findings may be associated with certain conditions. For example, in oral reading comprehension, three studies have shown average performance when passages are short, and decoding is adequate; however, problems arise with longer texts or higher attentional demands (40, 51, 52). In syllable or word reading accuracy, one study reported a relative strength in decoding accuracy in children with ADHD, suggesting that difficulties may lie in speed and fluency rather than accuracy (41). Finally, regarding sentence and text reading accuracy, it has been reported that children with ADHD without dyslexia maintain accuracy in text reading, although at a lower rate/fluency (40).

Sentence reading comprehension and nonword reading accuracy tests did not differ from normative values and aligned with another study reporting similar patterns (51).

In word writing accuracy and phonemic perceptual abilities, our findings indicate statistically significant performance advantages in girls, results not consistent with previous studies. It is therefore plausible to propose the existence of neurobiological mechanisms explaining this finding. For example, early maturation and increased connectivity of language networks, including properties of the arcuate fasciculus, may support phonological/orthographic performance in girls, potentially contributing to higher achievement compared to boys (12). These considerations warrant further investigation to validate this hypothesis.

Findings concerning the domain of comprehension and oral production in children with ADHD showed lower performance in silent reading, possibly due to difficulty maintaining internal attention without external feedback, with girls outperforming boys. In addition, lower performance with sex differences favoring girls was observed in right/left comprehension skills.

Our study found reduced performance in silent reading speed, consistent with results linking this measure to deficits in inhibitory control, particularly affecting internal reading (18, 43). By contrast, preserved performance in oral reading speed is consistent with the view that reading difficulties in ADHD are more closely related to accuracy than to speed (53), particularly when tasks do not require deep comprehension (11). Superior performance in sentence writing accuracy, especially in girls, is consistent with studies emphasizing better verbal self-control and less language deterioration in this population (54, 55).

Regarding spatial tasks, right/left comprehension skills showed poor performance, consistent with two studies reporting that children with ADHD scored significantly lower on right/left tasks due to visuospatial attentional asymmetries (e.g., atypical rightward bias and disrupted right fronto-parietal networks), which may impact tasks requiring spatial orientation and body perspective (53, 56). Additionally, another study found poor performance in children with ADHD when assessing identification of body parts through verbal commands (57). Notably, this study observed a significant sex difference in performance, with girls outperforming boys; however, no other studies support this finding. This difference may be due to girls engaging more prefrontal areas in such tasks compared to boys, suggesting greater top-down control in right/left comprehension abilities (58).

Tasks involving right/left expression and distinguishing drawings by angles showed no differences relative to the ENI-2 normative value. Preservation of these tasks is consistent with research indicating that, in the absence of highly structured or verbally demanding tasks, such abilities are not typically compromised in ADHD (19, 41, 59).

In the domain of verbal fluency and lexical access in children with ADHD, results showed below-average performance overall. Cancellation tasks suggested impairments in sustained attention and processing speed. Phonemic verbal fluency was also compromised, affecting verbal planning, and semantic verbal fluency showed lower performance, with girls outperforming boys.

Findings of poor performance in figure and letter cancellation tasks correspond to studies documenting impairments in visual and alphanumeric cancellation tasks, characterized by lower accuracy and high intra-individual variability in children with ADHD (11, 20, 50, 51).

Furthermore, the phonemic verbal fluency impairment found in our study has been previously reported (31, 60-63). Similarly, the reduced performance in semantic verbal fluency with fruits, with less impairment in girls than in boys, aligns with research indicating deficits in semantic fluency in this population, as well as evidence of girls' better overall linguistic development (64, 65).

It is important to acknowledge the limitations of this study. First, given that the patients were recruited from a specialized private center and predominantly belong to middle- and high-socioeconomic backgrounds, the findings may not necessarily be generalizable to individuals from lower socioeconomic levels. Second, participants were characterized based on the normative values of the ENI-2, but no comparison was made with a local sample of children without ADHD. Finally, given the high comorbidity between ADHD and other mental disorders, future studies should examine the influence of these comorbidities on cognitive functions.

CONCLUSIONS

Overall, the findings of this study indicate that children with ADHD, in the domain of memory and information encoding, show poor performance in auditory–verbal and visual memory, both encoding and delayed recall, as well as in complex figure copy, with girls performing better in verbal tasks and simple figure copy. In the language and phonological processing domain, poor performance was observed in syllable writing accuracy, nonword writing accuracy, phonemic perceptual abilities, silent reading comprehension, word reading accuracy, and metalinguistic abilities, with better performance in girls for word writing accuracy and phonemic perceptual skills. In the domain of comprehension and oral production, reduced performance was found in silent reading speed and right/left comprehension skills, alongside higher performance in sentence writing accuracy and oral reading speed, with girls outperforming boys in sentence writing accuracy. Finally, in verbal fluency and lexical access, low performance was observed in cancellation tasks, phonemic fluency, and semantic fluency, with the latter showing better performance in girls.

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AFA: study conception and design, interpretation of results, writing of the article, and approval of the final version of the article.
JVD: study design, data analysis, critical review, translation of the article, and approval of the final version.
RST: data recording, critical review of data analysis, and approval of the final version.
PFC: data acquisition, analysis of the quality of information recording, and interpretation of measurement instruments and scales.
AOY: study design, data analysis and interpretation, writing the draft article, and approval of the final version.

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