Cognitive correlates of ADHD subtypes and its association with self-esteem: A quantitative difference

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Abstract

Background : Attention-deficit hyperactivity disorder (ADHD) is a major neurodevelopmental disorder with heterogeneous symptoms, subtypes and cognitive deficits. Cognitive deficits are central to ADHD pathophysiology and one potential source of heterogeneity in ADHD. Subtype-specific cognitive correlates are not, however, well-studied. We explored cognitive correlates of ADHD subtypes based on the Wechsler Intelligence Scale for Children (WISC-IV) scores. We also assessed subtype-specific self-esteem ratings and its association with subtype-specific cognitive correlates.

Methods : 139 ADHD children (80.6% boy, 19.4% girl) were categorized into the predominantly “hyperactive (ADHD-H)”, “inattentive (ADHD-I)” and “combined (ADHD-C)” subtype based on their symptoms and scores on the Kiddie Schedule for Affective Disorders and Schizophrenia (K-SADS-PL) and Conners Parent-Rating Scale (CPRS-RS). They were then individually administrated the WISC-IV and completed a self-esteem inventory. Group differences in the WISC-IV indices and their predictability in discriminating ADHD subtypes were analyzed.

Results : We found a quantitative differentiation of cognitive abilities among ADHD subtypes with “working memory” as the most compromised cognitive domain. ADHD-I had the poorest cognitive profile while ADHD-H scored highest in all cognitive domains. Importantly, cognitive abilities were negatively correlated with inattention and positively correlated with hyperactive symptoms. Moreover, self-esteem ratings were positively correlated with the cognitive domains and were rated differently based on the subtype. ADHD-H, with the highest cognitive strength, reported the highest level of self-esteem among all subtypes.

Conclusions : ADHD subtype-specific symptoms, cognitive deficits, and social functioning should be considered for precise diagnosis and effective treatment. Our findings have implications for diagnosis precision and personalized intervention in ADHD. Cognitive interventions might be more compatible with and effective in inattentive and combined subtypes of ADHD. Working memory improving-based interventions can benefit all ADHD subtypes.

1. Background

Attention-deficit hyperactivity disorder (ADHD) is a major neurodevelopmental disorder with *heterogeneous* symptoms, subtypes and treatment response. A precise description of the pathophysiology underlying ADHD is difficult due to its neuropsychological heterogeneity [1] and substantial overlap between ADHD and typically developing children [2]. Cognitive deficits, especially executive dysfunctions, are central to ADHD psychopathology [3] and among the primary treatment targets by pharmacological [4] and novel treatment approaches [5]. These cognitive deficits are also heterogeneous in ADHD and considering individual differences in cognitive profile is suggested for precise ADHD diagnosis [6]. One aspect of heterogeneity in ADHD symptoms and cognitive deficits is its subtypes [7, 8] which includes a predominantly hyperactive (ADHD-H), inattentive (ADHD-I), and combined (ADHD-C) subtype. These subtypes are discerned from each other by the presence of specific symptoms, however, little is known about neuro-functional and cognitive differentiation of ADHD subtypes [9].

Furthermore, it is still elusive whether a specific subtype is critical to consider when examining treatment effects. For example, a recent study suggests that the effectiveness of neurofeedback treatment on the executive functioning of ADHD children is subtype-specific [10]. ADHD-I showed improved performance on the execution of an action in an experimental Go/NoGo task while the ADHD-C showed improved ability to withhold a prepotent response tendency in NoGo trials. A review of the non-invasive brain stimulation studies in ADHD also suggests that the efficacy of the treatment could be different in ADHD subtypes [5]. Identifying subtype-specific profiles in ADHD, especially cognitive profile, is thus a timely and important topic in the field.

Previous studies showed that the Wechsler Intelligence Scale for Children (WISC) provides a relatively comprehensive profile of cognitive strengths and weaknesses and is commonly used for cognitive evaluation in the clinical pediatric population. Application of WISC in ADHD also confirms that it reliably differentiates between ADHD patients and healthy controls [11, 12]. Moreover, it can provide knowledge about specific cognitive strengths and weaknesses in ADHD [13–17], used in designing therapeutic and educational interventions, and employed as diagnostic marker in ADHD children [13, 18–20]. However, the cognitive strengths and weaknesses of ADHD *subtypes* are not adequately explores in the previous studies in ADHD while several neuropsychological distinctions in ADHD subtypes (especially ADHD-I vs ADHD-C) have been identified [21].

Similar to subtype-specific cognitive deficits, self-esteem and social functioning in ADHD subtypes are not well-studied and the available studies are even more limited. Lower ratings of self-esteem in ADHD patients compared to the healthy control, regardless of ADHD subtypes, have been reported in previous studies [22–24]. These studies also showed that the treatment of ADHD symptoms was associated with the improvement of self-esteem scores [23] suggesting that self-esteem and ADHD symptoms (including cognitive deficits) are relevant for treatment efficacy. Nevertheless, subtypes-specific ratings of self-esteem and its association with cognitive deficits require further investigation.

The purpose of the present study was, therefore, to explore cognitive correlates of ADHD subtypes based on the WISC-IV scores in a relatively large sample size ($n = 139$). We also performed a discriminative analysis to evaluate if the cognitive profile of each ADHD subtype can predict group membership. We further assessed the level of self-esteem in each ADHD subtypes to determine any associations between subtype-specific cognitive correlates and self-esteem ratings in ADHD.

2. Methods

2.1. Participants

139 children with ADHD (80.6% boy, 19.4% girl, mean age = 8.20 ± 2.50), referred to the Fatemi Hospital of the correspondent University, were included in this study. The inclusion criteria were: (1) ADHD diagnosis according to the DMS-5 criteria by a licensed psychiatrist and a child psychologist, (2) parent or teacher report of ADHD symptoms as often or very much in addition to independent diagnosis made by psychiatrist/psychologist, (3) being 6–15 years old, (4) and no current and history of psychiatric and neurodevelopmental disorders, intellectual disabilities, and chronic physical illness. All participants were on medication treatment when recruited for the experiment however, there were prevented from the medication 24 h before testing to ensure that WISC-IV performance was not affected by medication as suggested by previous studies [17, 25, 26]. The study was performed according to the latest version of the Declaration of Helsinki and approved by the ethics committee of the local University. Participants' parents were instructed about experimental procedures and gave their written informed consent.

2.2. Measures

K-SADS-PL. The K-SADS-PL (3) is a semi-structured interview for assessing psychiatric diagnoses in children and adolescents from 6–18 years old. It assesses the present, history of psychiatric disorders, and the severity of symptoms based on the DSM-IV. The K-SADS-PL-P is especially sensitive at diagnosing patients with ADHD, major depressive disorder, bipolar disorder, general anxiety disorder, post-traumatic stress disorder, and substance use disorder. The test-retest reliability and kappa coefficients are reported excellent for the present and lifetime diagnosis of major psychiatric disorders. A native-language version of the scale used in this study with good-to-excellent concurrent validity in diagnosing current major disorders [27]. The Kappa agreements for most diagnoses are higher than 0.4 and the test-retest reliability is 0.87.

Conners' Parent Rating Scale-Revised: Short Version (CPRS-RS). The revised version of Conners' Rating Scale [28] has three forms; parent, teacher and self-report form and each form has a short and long version. The CPRS-RS used in this study contains 27 items and measures symptoms in four subscales: 1) oppositional subscale, 2) inattention, 3) hyperactive/impulsive, and 4) ADHD Index. The items are based on DSM diagnostic criteria for ADHD. Psychometric properties of the CPRS-RS are reported adequate as demonstrated by good internal reliability coefficients, high test-retest reliability and effective discriminative power [29]. The psychometric properties of the native version of the CPRS are reported good and reliable and demonstrated to be useful in discriminating children with ADHD from typically developing individuals [30].

Wechsler Intelligence Scale for Children (WISC-IV). The WISC-IV is an individually administered test battery that assesses intelligence in school-aged children (from 6 to 16 years of age) [31, 32]. The 4th edition included 10 subtests yielding to four index scores that combine into one FSIQ. The index scores include (1) Verbal Comprehension Index (VCI), (2) Perceptual Reasoning Index (PRI), (3) Work Memory Index (WMI), and (4) Processing Speed Index (PSI). Analyzing WISC-IV profiles are suggested useful differential diagnosis tools, particularly in distinguishing between "real ADHD" and pseudo-ADHD [33, 34].

Coopersmith Self-esteem (CSE) Inventory

The 58-items CSE with high reliability of 0.88 and validity [35] was used to measure the level of self-esteem in participants. Self-esteem total scores range from 0–50. Scores higher than 25 indicate high levels and scores lower than 25 indicate a low level of self-esteem. The CSE has reliability and validity [36] and the Cronbach's α coefficient and split-half reliability are reported to be 0.83 and 0.84, respectively [37, 38]. CSE measures self-esteem in four subscales (e.g., global, social, family, educational/professional), each with a separate score, and also provides a score of the general level of self-esteem.

2.3. Procedure

139 children in this study were consecutive referrals to our child psychiatry hospital who were diagnosed with ADHD. After we received institutional review board approval, ADHD children and their parents were interviewed by a psychiatrist based on the CPRS-RS and K-SADS-PL and were categorized into ADHD-I, ADHD-H, and ADHD-C accordingly. 24 h before the testing day, the patients that were on medication stopped taking the medication. They were then administrated the WISC-IV and also completed the self-esteem inventory. All tests were conducted in the same testing room. The order of tests were randomized.

2.4. Statistical analysis

We used IBM Statistical Package for the Social Sciences (SPSS) for Windows, version 24 (SPSS Inc, Chicago, IL, USA) for data analysis. A one-way analysis of variance (ANOVA) and Bonferroni-corrected t-tests were applied to examine group differences for the major WISC-IV indices, including the VCI, PRI, WMI, PSI, and the full-scale intelligence quotient (FSIQ). A separate similar ANOVA was conducted on the self-esteem domain. Our data met the ANOVA linear assumptions and Leven's test was used to examine the homogeneity of variances. Additionally, we performed a discriminant analysis to explore whether WISC-IV indices scores, as predictor variables, can predict grouping of ADHD patients into ADHD-I, ADHD-H, and ADHD-C subtypes. Correlational analyses between the outcome measures were calculated using the Pearson correlation (two-tailed). A significance level of $p < .05$ was used for all statistical comparisons.

3. Results

3.1. Data overview

Demographic information is summarized in Table 1. In all children (regardless of ADHD subtype), WMI was the weakest, and VCI was the strongest index, and FSIQ score was 3 points lower than 90. The ADHD-I group had lower scores in FSIQ and in all indices than the ADHD-H and ADHD-C groups (Fig. 1). The WMI was the lowest index in all three groups. The mean of self-esteem rating across ADHD subtypes are shown in Table 2 and Fig. 2.

Table 1
Demographic information

Demographic information					
Variable			**value**	p	Group difference*
Sample size (*n*)			139		
	subtype	ADHD-H (%)	71 (51.1%)		
		ADHD-I (%)	35 (25.2%)		
		ADHD-C (%)	33 (23.7)		
Age	Mean (SD)	Total	8.20 (2.50)	0.001	ADHD-H > ADHD-I
		ADHD-H	7.45 (2.45)		
		ADHD-I	9.54 (2.29)		
		ADHD-C	8.42 (2.26)		
Child order among siblings	1st	ADHD-H/I/C	41 / 18 / 27		
	2nd	ADHD-H/I/C	22 / 8 / 5		
	3rd	ADHD-H/I/C	8 / 7 / 0		
	4th	ADHD-H/I/C	0 / 1 / 0		
	5th and higher	ADHD-H/I/C	0 / 1 / 1		
Gender (*n*)	Male (female)		112 (27)		
CPRS-RS	Inattaention	ADHD-H (SD)	26.97 (4.81)	0.001	ADHD-I > ADHD-H
		ADHD-I (SD)	40.60 (4.37)		ADHD-C > ADHD-H
		ADHD-C (SD)	42.72 (4.48)		
	Hyperactivity	ADHD-H (SD)	33.11 (4.37)	0.001	ADHD-H > ADHD-I
		ADHD-I (SD)	23.42 (4.69)		ADHD-C > ADHD-I
		ADHD-C (SD)	40.66 (4.18)		
	ADHD-index	ADHD-H (SD)	59.14 (4.54)	0.001	ADHD-C > ADHD-I
		ADHD-I (SD)	64.42 (6.26)		ADHD-C > ADHD-H
		ADHD-C (SD)	83.30 (7.40)		ADHD-H > ADHD-C

Table 2
ANOVA results for the group differences in the WISC indices and self-esteem rating

WISC-IV							
variable	**indices**	**Group Mean (SD)**					
		ADHD-H	**ADHD-I**	**ADHD-C**	**F**	**p-value**	η_p^2
WISC-IV	VCI	99.94 (18.27)	85.74 (17.72)	96.06 (16.58)	7.52	**.001**	**.10**
	PRI	94.90 (9.22)	85.25 (20.47)	91.42 (14.08)	5.58	**.005**	**.076**
	WMI	82.19 (18.59)	72.37 (16.44)	79.18 (15.57)	3.74	**.026**	**.052**
	PSI	99.64 (15.83)	83.28 (16.98)	93.90 (17.35)	11.48	**.001**	**.144**
	FSIQ	92.00 (15.12)	77.77 (17.77)	87.06 (15.63)	9.33	**.001**	**.121**
Self-esteem (CSE)							
variable	**domain**	**Group Mean (SD)**					
		ADHD-H	**ADHD-I**	**ADHD-C**	**F**	**p-value**	η_p^2
CSE	Global	21.11 (2.18)	18.14 (3.44)	17.06 (3.89)	24.65	**.001**	**.266**
	Total	38.52 (5.79)	33.00 (8.18)	32.30 (7.00)	13.18	**.001**	**.162**
	Social	6.45 (1.54)	5.57 (2.26)	5.69 (1.64)	3.72	**.027**	**.052**
	Educational	4.94 (1.88)	3.82 (2.39)	4.12 (2.24)	3.85	**.024**	**.054**
	Family	5.98 (1.93)	5.45 (1.40)	5.42 (1.75)	1.64	**.198**	**.024**

Note: WISC = Wechsler Intelligence Scale for Children; ADHD-H: predominantly hyperactive; ADHD-I: predominantly inattentive; ADHD-C: combined; VCI = Verbal Comprehension Index; PRI = Perceptual Reasoning Index; WMI = Working Memory Index; PSI = Processing Speed Index; FSIQ = Full-Scale Intelligence Quotient; CSE = Coopersmith Self-esteem Inventory; Post-hoc comparisons were conducted using the Bonferroni-corrected post-hoc t-tests. All error bars represent s.e.m; significant results are bolded ($p < 0.5$).

Cognitive profile differences in ADHD subtypes

Significant differences between ADHD subtypes were revealed in the FSIQ and all indices of VCI, PRI, WMI, and PSI (Fig. 1, Table 2). Bonferroni-corrected post *hoc* t-tests revealed that ADHD-I, compared to the ADHD-H, scored lower in the FSIQ ($t = 4.21$, $p < 0.001$) and all indices of VCI ($t = 4.20$, $p < 0.001$), PRI ($t = 2.85$, $p = 0.013$), WMI ($t = 2.90$, $p = 0.011$), and PSI ($t = 4.84$, $p < 0.001$). Moreover, ADHD-I scores in the VCI ($t = 2.59$, $p = 0.028$) and PSI ($t = 2.67$, $p = 0.023$) indices were significantly lower than ADHD-C. No significant difference between ADHD-H vs ADHD-C was found in any of the indices. All ADHD subtypes showed the worst performance in the WMI (Fig. 1).

3.2. Discriminant analysis and predictive ability

We used discriminant analysis to see whether subtests scores of the WISC-IV, as predictor variables, can predict grouping of ADHD patients into ADHD-I, ADHD-H, and ADHD-C. Results of the discriminant analysis showed a significant function ($p = 0.001$) that accounted for 90.7% of the discriminative ability of the WISC-IV subtests in predicting ADHD group membership (Chi-square = 113.27, df = 20, $p = 0.001$). The canonical correlation between predictor variables and grouping was R = 0.727. Correct grouping of the function for ADHD-I, ADHD-H, and ADHD-C was 57.1%, 84.5%, and 45.5% respectively. Moreover, the discriminant function could correctly classify 68.3% of the individuals or identified the group to which the individuals belong. Finally, we calculated coefficients of the WISC-IV subtests, which can specify the contribution of each WISC-IV subtests to distinguishing or discriminating ADHD subtypes. The vocabularies (0.508), similarities (0.364) and symbol search (0.258) subscales had the most significant correlation with a discriminant function.

3.3. Self-esteem rating

Results of the ANOVA showed significant differences between ADHD subtypes in all self-esteem domains including global, social, educational, family and total self-esteem a significant main effect of subtypes was found (Table 2). Bonferroni-corrected post *hoc* analysis revealed that ADHD-H had a significantly higher *total* self-esteem compared with ADHD-I ($t = 7.39$, $p < 0.001$) and ADHD-C ($t = 8.16$, $p < 0.001$). Similarly, ADHD-H patients had a significantly higher *global* self-esteem compared with ADHD-I ($t = 3.97$, $p < 0.001$) and ADHD-C ($t = 5.32$, $p < 0.001$). No significant differences were found in the subdomains of self-esteem between the groups.

3.4. Correlational analyses

Cognitive indices of the WICS-IV were positively correlated with ratings of self-esteem indicating that cognitive deficits were associated with lower self-esteem. This positive correlation was observed with all of the WICS-IV indices (VCI, PRI, WMI, PSI, FSIQ) and all of the self-esteem domain except for the family self-esteem (Table 3). Furthermore, we found interesting associations between the WICS-IV indices and attentional vs hyperactivity scores. Cognitive deficits were negatively correlated with attentional symptoms which means that more attentional deficits were associated with poor performance on the WICS-IV indices. In contrast, performance on the WICS-IV indices was positively correlated with hyperactivity/impulsivity symptoms (Table 2). This pattern of association is in line with the quantitative difference between the ADHD-I and ADHD-H with better scores on WICS-IV indices for the latter group. Finally, all of the self-esteem domains, except for the family self-esteem, were negatively correlated with inattention symptoms but not hyperactivity.

Table 3
Correlational analyses between WISC-IV indices and CSE self-esteem domains

	Global SE	Total SE	Family SE	Social SE	Educational SE	inattention	hyperactivity	ADHD index
FSIQ	**0.520****	**0.576****	0.069	**0.546****	**0.600****	**-0.334****	**0.182***	-0.156
VCI	**0.505****	**0.541****	0.008	**0.519****	**0.580****	**-0.256****	**0.203***	-0.083
PRI	**0.427****	**0.463****	0.051	**0.453****	**0.465****	**-0.379****	0.162	**-0.216****
WMI	**0.468****	**0.503****	0.104	**0.455****	**0.479****	-0.166	0.076	-0.078
PSI	**0.391****	**0.482****	0.107	**0.442****	**0.540****	**-0.318****	**0.189***	-0.129
Global SE	-	-	-	-	-	**-0.473****	-0.025	**-0.415****
Total SE	-	-	-	-	-	**-0.387****	-0.003	**-0.303****
Family SE	-	-	-	-	-	-0.066	-0.161	-0.101
Social SE	-	-	-	-	-	**-0.244****	0.018	**-0.177****
Educational SE	-	-	-	-	-	**-0.289****	0.137	-0.132

Note: WISC = Wechsler Intelligence Scale for Children; ADHD-H: predominantly hyperactive; ADHD-I: predominantly inattentive; ADHD-C: combined; VCI = Verbal Comprehension Index; PRI = Perceptual Reasoning Index; WMI = Working Memory Index; PSI = Processing Speed Index; FSIQ = Full-Scale Intelligence Quotient; SE Self-esteem; All analyses are with Pearson correlation; *= correlation is significant at 0.05 (two-tailed); **= correlation is significant at 0.01 (two-tailed); Significant results are bolded.

4. Discussion

In the present study we explored subtype-specific cognitive correlates based on the WISC-IV in 139 children with ADHD. We also assessed self-esteem ratings in ADHD subtypes. Our results show that ADHD-I has the most impaired cognitive profile among all ADHD subtypes and is mostly discriminated with ADHD-H, with the least impaired cognitive deficits. This finding suggest a quantitative differentiation of cognitive profiles among ADHD subtypes with working memory as the most compromised cognitive domain with the lowest value in ADHD-I. Moreover, we found a subtype-specific difference in self-esteem rating with a significantly higher rated self-esteem scores in ADHD-H compared to the other two subtypes.

With regard to subtype-specific cognitive correlates, we found a quantitative differentiation of cognitive profiles among ADHD subtypes regardless of WISC-IV domains. This suggests that all ADHD subtypes display similar cognitive deficits with WM as the most impaired domain but the extent to which ADHD symptoms are close to inattentive vs hyperactive subtype determines the level of impairment. This is in line with results of Roberts et al. (2017) which they found group difference in executive dysfunction of ADHD subtypes based on gradations of EF impairments. The group with poor set-shifting/speed, close to ADHD-I subtype in our study, was the most severely impaired one and the intact task performance group (close to ADHD-H in our study) was relatively unimpaired in executive functioning task performance [6]. This finding is in line with a previous study based on a sample size of 1038 ADHD children with cognitive subtype (close to ADHD-I in our sample) exhibit information processing deficits (PSI index in our sample) compared to subtypes with more predominately behavioral problems (ADHD-H in our sample) [39]. This study also reported that ADHD subtypes can be described on a continuum of severity which is supported by our findings.

One important aspect of our findings was that WM is the poorest cognitive domain in all ADHD subtypes especially in the ADHD-I. Previous studies using the Wechsler Intelligence Scale in both children and adults with ADHD, regardless of subtype, showed that working memory and processing speed are usually among the most impaired domains in ADHD patients compared to healthy controls [11, 17, 25, 40]. A recent study that comprehensively examined executive functioning heterogeneity in pediatric ADHD using neuropsychological battery also found a positive association between impaired working memory and exhibiting higher ADHD symptoms [41]. Our results are generally in line with these studies by showing WM as the most impaired domain in all *subtypes*. More importantly, this is in line with a recently introduced model of ADHD psychopathology, which proposes WM deficits as a major risk factor in ADHD [42] and implies that WM is probably one of the core cognitive deficits in the pathophysiology of all ADHD subtypes, and could be a reasonable target for ADHD treatment.

In addition to the cognitive correlates, we found a subtype-specific pattern in self-esteem ratings with ADHD-I reporting a higher level of global and total self-esteem compared to other subtypes. Previous studies documented social impairment in ADHD and emphasized on the need for subtype-specific social deficits in ADHD [43]. Our results showed that self-esteem ratings of children with ADHD follow the same quantitative pattern of response in cognitive correlates. In other words, those subtypes with more severe cognitive deficits had the lowest level of self-esteem as well which was supported by the negative correlation between the self-esteem domains and cognitive correlates. The association of subtype-specific cognitive correlates and self-esteem rating is novel and not well-studies by previous works.

Taken together, our results show that there is subtype-specific cognitive profile in ADHD confirming a cognitive heterogeneity in ADHD in line with recent evidence [41]. ADHD subtype is an important contributing factor not only to cognitive strength/weakness but also self-esteem ratings. These results have implications for diagnosis precision and personalized in ADHD patients. For instance, cognitive interventions are among the major treatments in ADHD which might be more compatible with and effective in ADHD-I or ADHD-C subtypes due to more severe cognitive weaknesses. Similarly, social interventions and self-esteem can be more effectively addressed in the subtypes with lower self-esteem ratings. The need for the individualized and personalized treatment approach in ADHD is supported more than before from the neurobiological differences of ADHD subtypes [9] and is required due to heterogeneity of ADHD symptoms.

The following limitations should be considered. First, we did not have a control group consisting of typically developing children because the purpose of this study was to determine subtype-specific cognitive differences in ADHD. Nevertheless, comparison with typically developing children can also reveal insightful differences of ADHD children compared to their healthy peers. Second, because we did not intend to focus on gender differences, the number of girls in the study was small and need to be explored in larger samples. Lastly, the WISC-IV indices might not examine specific aspects of cognition in ADHD and cognitive profile of ADHD subtypes needs to be explored with more specific cognitive measures of executive functions, such as cold vs hot executive functions [44]. These limitations notwithstanding, our ADHD sample were recruited from clinical settings, rather than community, and could have clinical implications.

5. Conclusions

We found a subtype-specific quantitative difference in cognitive correlates and self-esteem ratings of ADHD patients which should be considered for precise diagnosis and individualized interventions. Our findings support the notion that ADHD is characterized by neurocognitive heterogeneity. Cognitive interventions might be more compatible with and effective in inattentive and combined subtypes of ADHD. Working memory improving-based interventions can benefit all ADHD subtypes.

Abbreviations

ADHD: Attention-deficit hyperactivity disorder, ADHD-C: combined, ADHD-H: predominantly hyperactive, ADHD-I: predominantly inattentive, CPRS-RS: Conners Parent Rating Scale-Revised Short, DSM-5: Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, FSIQ: Full-Scale Intelligence Quotient, Verbal Comprehension Index (VCI), Perceptual Reasoning Index (PRI), Working Memory Index (WMI), and Processing Speed Index (PSI). CSE: Coopersmith self-esteem Inventory.

Declarations

Ethics approval and consent to participate

The protocol was conducted in accordance with the latest version of the Declaration of Helsinki and was approved by the Institutional Review Board and ethical committee at the Ardabil University of Medical Sciences.

Consent for publication

All participants' parents were instructed about experimental procedures and gave their written informed consent.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interest statement

MAN is a member of the Scientific Advisory Board of Neuroelectrics. All other authors declare no competing interests.

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None

Authors' contributions

PM & MN conceived the study. HS & MN collected the data. MN and MAS analyzed and interpreted the data. MAS wrote the first draft. MAN, CV, & MAS revised and reviewed. All authors read and approved the final manuscript.

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Figures

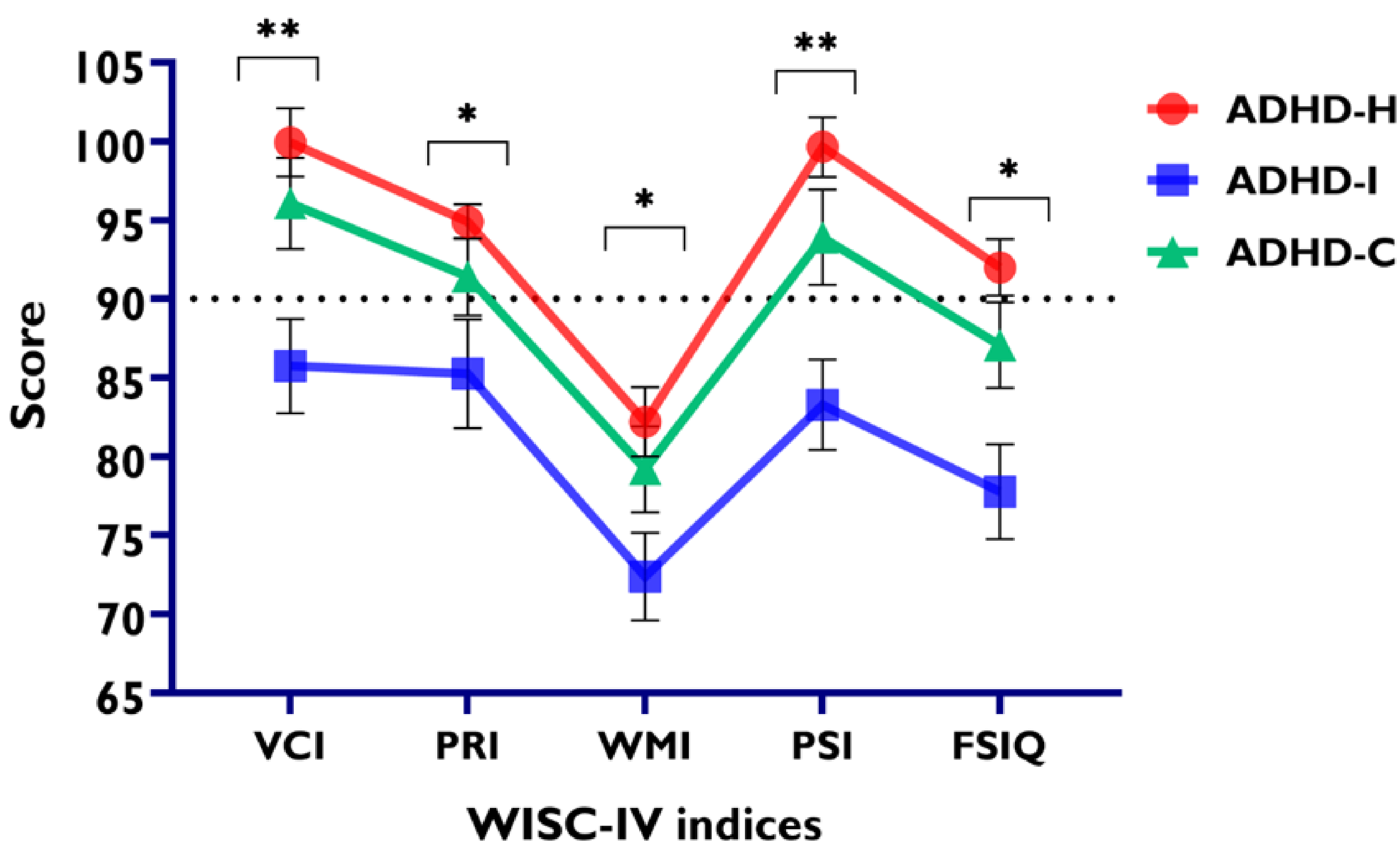

Figure 1

Mean of the WISC index scores and FSIQ in ADHD subtypes (n = 139) Note: ADHD-H: predominantly hyperactive; ADHD-I: predominantly inattentive; ADHD-C: combined; VCI = Verbal Comprehension Index; PRI = Perceptual Reasoning Index; WMI = Working Memory Index; PSI = Processing Speed Index; FSIQ = Full-Scale Intelligence Quotient; * = indicates significant difference of ADHD-I vs ADHD-H; ** = indicates significant difference of the ADHD-I group vs both, ADHD-H and ADHD-C groups. Post-hoc comparisons were conducted using the Bonferroni-corrected post hoc t-tests. All error bars represent standard error of mean (SEM).

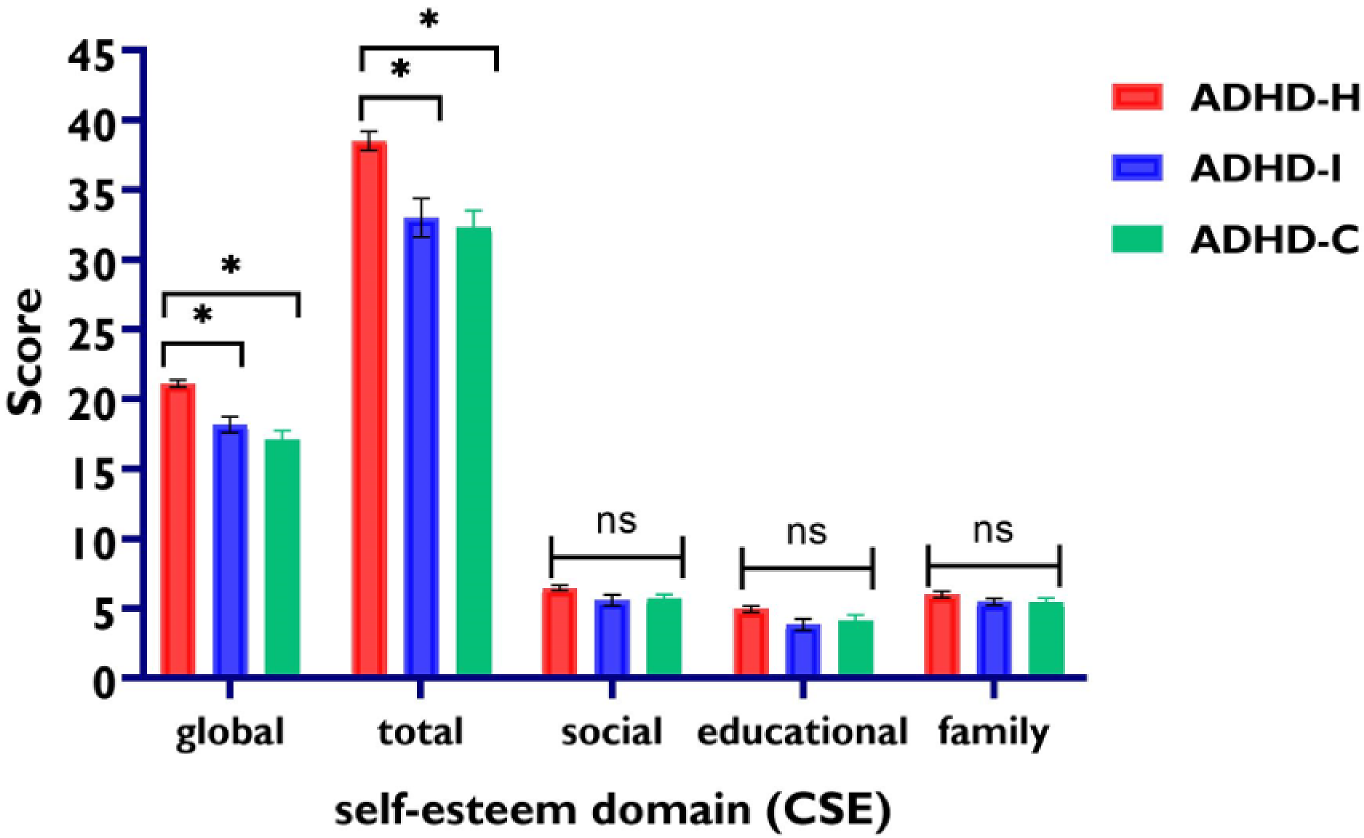

Figure 2

Mean of the self-esteem domains scores in ADHD subtypes (n = 139) Note: ADHD-H: predominantly hyperactive; ADHD-I: predominantly inattentive; ADHD-C: combined; CSE = Coopersmith self-esteem Inventory; * = indicates significant difference. Post hoc comparisons were conducted using the Bonferroni-corrected post hoc t-tests. All error bars represent standard error of mean (SEM)