Clinical Usefulness of CNS Vital Signs for Assessing Neurocognition in ADHD

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Introduction

The neuropsychological problems associated with ADHD in children have been well documented, and typically are characterized as core deficits in attention and executive functioning.

Neuropsychological testing in ADHD research typically involves traditional paper-pencil and manual-performance measures.

Computerized neuropsychological batteries have been used less frequently, but are becoming more popular in ADHD clinical research.

Purpose: To illustrate a clinical methodology for identifying frank neurocognitive deficits in children and adolescents with ADHD.

Participants

50 children and adolescents between the ages of 7 and 18 years (mean=12.9, SD=3.0) who were diagnosed with Attention Deficit Hyperactivity Disorder (ADHD).

Clinicians at the North Carolina Neuropsychiatry Clinics gave a primary diagnosis of ADHD to all patients according to the Diagnostic and Statistical Manual of Mental Disorders – Fourth Edition

All patients were medication-free (ADHD-untreated) at the time of their evaluation, which included brief computerized neurocognitive testing using the CNS Vital Signs battery.

Patients with untreated ADHD were compared to 50 age-matched children and adolescents between 7 and 18 years (mean=12.9, SD=3.0; $t(98)=0.03$, $p=.97$) who were selected from the CNS Vital Signs normative database.

Measures

CNS Vital Signs is comprised of seven common neuropsychological measures, including verbal and visual memory, finger tapping, symbol digit coding, the Stroop test, a shifting attention test, and a continuous performance test.

The battery generates 15 primary scores, which are used to calculate 5 domain scores (Memory, Psychomotor Speed, Reaction Time, Cognitive Flexibility, and Complex Attention) and a summary score (Neurocognition Index).

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Results

There was a significant multivariate effect [Wilks' Lambda=0.81; $F(5,94)=4.50$, $p=.001$, partial eta squared=.193].

The univariate ANOVA results revealed significantly worse neuropsychological test scores for those in the ADHD group on the Memory (Cohen's d=.45), Psychomotor Speed (d=.48), Cognitive Flexibility (d=.80), and Complex Attention (d=.97) domains.

The groups did not differ on the Reaction Time domain ($p = .088$, d=.35).

In the ADHD sample, 56% obtained two or more scores below 1 SD, compared to 26% of the control group [$\chi^2(1)=9.30$, $p=.002$; Odds Ratio=3.6, 95% CI=1.6 – 8.4].

Applying the 5th percentile as the cutoff, 40% of the ADHD sample and 10% of the control sample obtained two or more low scores [$\chi^2(1)=12.0$, $p=.001$; Odds Ratio=6.0, 95% CI=2.1 – 17.1].

In the ADHD sample, 28% obtained two or more scores below 2 SD, compared to 4% of the control group [$\chi^2(1)=10.7$, $p=.001$; Odds Ratio=9.3, 95% CI=2.2 – 38.8].

Discussion

The results of this study are largely consistent with the neuropsychological theories and empirical studies on ADHD in children and adolescents.

Children and adolescents with ADHD performed more poorly on computerized tests of Memory, Psychomotor Speed, Cognitive Flexibility, and Complex Attention.

The largest effect sizes for the present study pertained to the two domains that could be considered the most consistent with more traditional measures of executive functioning and higher-order attentional capabilities (i.e., vigilance, response inhibition, alternating set, and rapid problem-solving), which are often identified as the core neurocognitive deficits in a subset of children with ADHD.

Children with ADHD were 9.3 times more likely to have two or more domain scores that were more than two standard deviations below the mean (95% CI=2.2 – 38.8).

The method for simultaneously interpreting the domain scores from this battery constitutes a unique approach that appears to identify the subset of children and adolescents with ADHD who present with neurocognitive deficits prior to receiving treatment.

Table 1. Descriptive statistics, mean comparisons, and effect sizes for the CNS Vital Signs scores.

Score	Group	Mean	Standard Deviation	ANOVA F (p)	Effect Size (Cohen's d)
Neurocognition Index	Control	100.1	12.8	18.26 (<.001)	0.86
	ADHD	87.4	16.6		
Memory	Control	101.4	14.7	4.77 (.031)	0.45
	ADHD	92.8	23.5		
Psychomotor Speed	Control	98.6	24.1	5.77 (.018)	0.48
	ADHD	87.0	24.1		
Reaction Time	Control	99.8	16.5	2.97 (.088)	0.35
	ADHD	93.9	17.7		
Cognitive Flexibility	Control	101.9	16.0	16.17 (<.001)	0.80
	ADHD	88.1	18.3		
Complex Attention	Control	101.0	17.8	22.96 (<.001)	0.97
	ADHD	80.6	24.3		

Note: By convention, effect sizes are interpreted as follows: .2 = small, .5 = medium, and .8 = large.

Table 2. Base rates of low domain scores in untreated ADHD and control.

Number of scores below cutoff	Untreated ADHD		Matched Controls		Number of scores below cutoff
	%	C%	%	C%	
< 1 SD					**< 1 SD**
5	4.0	4.0	2.0	2.0	5
4	18.0	22.0	2.0	4.0	4
3	16.0	38.0	14.0	18.0	3
2	18.0	56.0	8.0	26.0	2
1	18.0	74.0	22.0	48.0	1
0	26.0	100	52.0	100	0
< 10th %ile					**< 10th %ile**
5	4.0	4.0	--	--	5
4	10.0	14.0	4.0	4.0	4
3	20.0	34.0	6.0	10.0	3
2	14.0	48.0	10.0	20.0	2
1	12.0	60.0	18.0	38.0	1
0	40.0	100	62.0	100	0
≤ 5th %ile					**≤ 5th %ile**
5	--	--	--	--	5
4	12.0	12.0	--	--	4
3	10.0	22.0	6.0	6.0	3
2	18.0	40.0	4.0	10.0	2
1	12.0	52.0	18.0	28.0	1
0	48.0	100	72.0	100	0
< 2 SDs					**< 2 SDs**
5	--	--	--	--	5
4	2.0	2.0	--	--	4
3	10.0	12.0	--	--	3
2	16.0	28.0	4.0	4.0	2
1	18.0	46.0	16.0	20.0	1
0	54.0	100	80.0	100	0

Note: There are slight variations due to rounding. These base rates were calculated for the 5 domain scores, Memory, Psychomotor Speed, Reaction Time, Cognitive Flexibility, and Complex Attention.