Clinical Usefulness of CNS Vital Signs for Assessing Neurocognition in ADHD

Grant L. Iverson
University of British Columbia & British Columbia Mental Health & Addiction Services

Brian L. Brooks
British Columbia Mental Health & Addiction Services

Margaret D. Weiss
University of British Columbia & British Columbia Provincial ADHD Program

C. Thomas Gualtieri & Lynda G. Johnson
North Carolina Neuropsychiatry Clinics

Presented at: American Psychological Association, August 17-20 2007, San Francisco, CA.

Introduction

Attention-deficit hyperactivity disorder (ADHD) is a heterogeneous, long-course neurodevelopmental disorder with a strong genetic component . Children and adolescents with ADHD frequently have co-occurring conditions, such as depression, bipolar disorder, anxiety, and learning disabilities . The neuropsychological problems associated with ADHD in children have been well documented, and typically are characterized as core deficits in attention and executive functioning . Those with comorbid learning disabilities often have more pronounced neuropsychological deficits .

Neuropsychological testing in ADHD research typically involves traditional paper-pencil and manual-performance measures. Brief and comprehensive batteries have been used. Computerized continuous performance tests also are commonly used. Computerized neuropsychological screening batteries have been used less frequently, but are becoming more popular in ADHD clinical research (Rhodes et al., 2006; Rhodes et al., 2005; Goldberg et al., 2005; Mehta et al., 2004; Gualtieri & Johnson, 2006). The purpose of this study is to illustrate the clinical usefulness of the CNS-Vital Signs battery for identifying neurocognitive deficits in children and adolescents with ADHD.

Method

The clinical participants for this study included 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, Text Revision (DSM-IV-TR; American Psychiatric Association, 2000). Patients with comorbid diagnoses were excluded from this study. 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) who were selected from the CNS Vital Signs normative database.

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). Domain scores are presented as index scores, with a mean of 100 and standard deviation of 15.

Analysis of the CNS Vital Signs test results involved (a) examinations of the mean domain score performances across the groups using multivariate and univariate analyses of variance (MANOVA and ANOVA, respectively) and (b) examinations of the base rates of low domain scores across the two groups. The base rates of low scores were calculated by using four cutoff scores that might be routinely used in clinical practice, including: (a) more than 1 standard deviation (SD) below the mean, (b) below the 10^{th} percentile, (c) at or below the 5^{th} percentile, and (d) more than 2 SDs below the mean. For the domain scores, these cutoffs correspond to less than 85, below 81, at or below 76, and less than 70, respectively. Calculations for the base rates of low scores involve simultaneously examining all 5 domain scores (Memory, Psychomotor Speed, Reaction Time, Cognitive Flexibility, and Complex Attention), rather than performance on each domain in isolation.

Results

The two groups were compared on the five domain scores using multivariate analysis of variance (MANOVA) followed by univariate ANOVAs. MANOVA and ANOVA tend to be quite robust to violations of underlying general linear model assumptions. 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 domains (d=.97). The groups did not differ on the Reaction Time domain.

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]. When using two or more scores below the 10^{th} percentile as the cutoff, 48% of the ADHD sample and 20% of the control sample scored in this range [$\chi^2(1)$=8.7, p=.003; Odds Ratio=3.7, 95% CI=1.5 – 8.9]. 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

Computerized neuropsychological testing with CNS Vital Signs could be useful where the time and cost associated with traditional neuropsychological testing might not be justified. 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. These children and adolescents with untreated ADHD obtained significantly more low domain scores across all cutoff levels. As seen in clinical practice, a subset of unmedicated patients with ADHD have frank cognitive impairment. In this study, 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). Knowing the base rates of low scores in untreated ADHD and healthy control samples can facilitate interpretation of test scores in a busy clinical practice.