

Measuring ADHD behaviors in children with symptomatic accommodative dysfunction or convergence insufficiency: a preliminary study

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Background: Accommodative dysfunction and convergence insufficiency (CI) are common pediatric vision problems that have been associated with an increase in frequency and severity of vision-specific symptoms that affect children when doing schoolwork. However, the relationship between accommodative dysfunction and CI and other learning problems, such as attention deficit hyperactivity disorder (ADHD), are not well understood. The purpose of this study was to evaluate the frequency of ADHD behaviors in school-aged children with symptomatic accommodative dysfunction or CI.

Methods: Children 8 to 15 years of age with symptomatic accommodative dysfunction or CI were recruited from the teaching clinic at the Southern California College of Optometry. Children with learning disabilities or ADHD were excluded. One parent of each child completed the Conners Parent Rating Scale–Revised Short Form (CPRS-R:S). The children's scores on the CPRS-R:S were compared with the normative sample.

Results: Twenty-four children (9 boys and 15 girls) participated in the study with a mean age of 10.93 years (SD = 1.75). On the CPRS-R:S, cognitive problem/inattention, hyperactivity, and ADHD index were significantly different from normative values ($p \leq .001$ for all tests).

Conclusions: The results from this preliminary study suggest that school-aged children with symptomatic accommodative dysfunction or CI have a higher frequency of behaviors related to school performance and attention as measured by the CPRS-R:S.

Key Words: Attention deficit hyperactivity disorder, convergence insufficiency, accommodative insufficiency, learning disabilities, accommodation.

Attention deficit hyperactivity disorder (ADHD) is one of the most common behavioral disorders seen in children and affects between 4% and 12% of the school-aged population.¹ The condition is associated with behaviors that are classified as inattentive, hyperactive/impulsive, or a combination of both.² School performance as well as general quality of life can also be affected in children with ADHD.^{1,3} The relationship between various vision dysfunctions and learning problems such as ADHD is a controversial area within eye care because of inconsistent research results found when correlating vision deficits and school achievement.⁴ Recently, investigators^{5,6} have started to evaluate possible relationships between ADHD and vision problems in an effort to clarify some of the issues associated with assessing the role of vision dysfunctions in learning.

The relationship between vision problems and ADHD has focused on behaviors or symptoms that are associated with each condition. In a study comparing ADHD children with a non-ADHD group, Farrar et al.⁶ found that ADHD children scored higher on 14 of the 33 categories on the modified College of Optometrists in Vision Development (COVD) Quality of Life Outcomes Assessment. The investigators concluded that children with ADHD exhibit more visual and quality-of-life symptoms than children without ADHD. However, Farrar et al.⁶ did not find corresponding differences between the 2 groups when conducting a series of vision tests. Only accommodative facility was significantly different between the ADHD and non-ADHD groups. As a result, the higher frequency of visually related symptoms observed in the ADHD group could have been caused by attention problems. Using a case series ap-

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proach, Damari et al.⁵ reported that significant learning-related vision problems in children could be misdiagnosed as ADHD. However, the co-occurrence of ADHD and learning-related vision problems could not be ruled out in the case series. Thus, both Farrar et al.⁶ and Damari et al.⁵ showed a possible relationship between behaviors associated with ADHD and common symptoms of vision problems.

In contrast to the previous studies, Borsting et al.⁷ focused on a specific vision condition and found that children with a diagnosis of convergence insufficiency (CI) scored higher on the psychosomatic, learning problems, and hyperactive categories of the Connors Parent's Rating Scales when compared with a group of children with normal binocular vision. In this study, children with an existing diagnosis of ADHD were excluded. Borsting et al.⁷ noted that for children with CI, the most common behaviors reported by the parents on the Connors Parent's Rating Scales were "easily frustrated," "attention span problem," and "fails to finish things." One problem with the study by Borsting et al.⁷ was that the Connors Parent's Rating Scales did not include an ADHD scale consistent with current diagnostic and statistical manual guidelines for the diagnosis of ADHD. Another issue is that children with primary accommodative dysfunction were not included. To partially address these issues, we looked at the frequency of ADHD behaviors in a group of school-aged children with symptomatic accommodative dysfunction or CI but who had not been diagnosed with ADHD.

Methods

Sample Selection

Children ages 8 to 15 years with symptomatic accommodative dysfunction or CI (based on a diagnosis by the attending faculty) were recruited from the Vision Therapy Service at the Southern California College of Optometry from 2000 to 2003. If a subject met the criteria listed below, then that child was invited to participate in the study. The research study was approved by the Institutional Review Board at the Southern California College of Optometry. A parent provided written consent, and each child provided assent before any testing was done.

To participate in the study, subjects had to meet the following inclusion criteria: corrected visual acuity of 20/25 or better in each eye, no constant strabismus, and no significant ocular pathology and no existing vision therapy program. Subjects with refractive errors greater than 1.25 diopter sphere of hyperopia, 1.00 diopter sphere of anisometropia or 1.00 diopter of astigmatism, or greater than 0.50 diopter sphere of myopia wore refractive corrections for at least 1 month before participating in the experiment. Subjects with a diagnosis of a learning disability or ADHD (obtained by parental report) were excluded to eliminate potential bias on our measurement of ADHD-type behaviors.

To meet the criteria for the diagnosis of CI, all 3 of the following signs were required: (1) greater exophoria at near-than distance by 4 prism diopters, (2) failed Sheard's criteria or minimum normative positive fusional vergence at near (<15 prism diopters for break), and (3) receded near point of convergence (> 6 cm break point).⁸ To meet the diagnosis of accommodative dysfunction, the accommodative amplitude had to be at least 2 diopters below Hofstetter's minimum expected⁹ as measured by a push-up amplitude¹⁰ or monocular accommodative facility tested with ± 2.00 flipper lenses of 6 cycles per minute or less.¹¹ The diagnosis of accommodative insufficiency (AI) was derived from Borsting et al.¹⁰ where an amplitude accommodative of 2 diopters below Hofstetter's minimum expected was significantly associated with symptoms. This finding is also consistent with a recent study by Sterner et al.¹² that found that accommodative amplitudes of school-aged children were lower than predicted by Hofstetter's formula. The diagnosis of accommodative dysfunction or CI was confirmed by one of the investigators. In addition, each child had to show significant associated symptoms by scoring 16 or higher on the revised version of the Convergence Insufficiency Symptom Survey (CISS-V15) or a score of 9 or higher on the older version of the CISS as reported by the parent or the child.^{7,13}

Data Collection

One parent or guardian of each child was asked to complete the Connors Parent Rating Scale-Revised Short Form (CPRS-R:S) in a separate room while the child performed other activities. The CPRS-R:S uses 27 questions to evaluate a

broad range of school-related behaviors in the following categories: oppositional, cognitive problems/inattention, hyperactivity, and ADHD Index, and has normative data from 2,426 children ages 3 to 17 across the United States.³ The CPRS-R:S asks the parent to rate the frequency of behaviors observed during the last month as follows: "not true at all," "just a little true," "pretty much true," or "very much true." The CPRS-R:S was administered according to standardized instructions.³ The scores for the CPRS-R:S were converted to T-scores (mean of 50 and standard deviation of 10) according to the procedures outlined in the manual. Scores greater than 50 on the CPRS-R:S indicate a higher frequency of a behavior. The T-scores were then compared with the normative sample for the CPRS-R:S.

Calculating a sample size estimate was difficult because we had not administered the CRPS-R:S to a group of children with symptomatic accommodative dysfunction or CI. As a result, this preliminary study would indicate whether clinically significant differences exist in a small sample of school-aged children.

Results

Twenty-four children 8 to 15 years of age, with symptomatic accommodative dysfunction or CI participated in the study. The mean age of the subjects was 10.9 years (SD = 1.75), and there were 9 boys and 15 girls. Thirteen subjects had both CI and accommodative dysfunction, 2 subjects had only CI, and 9 subjects had only accommodative dysfunction.

The mean and SD for each category are as follows; oppositional (mean = 54, SD = 9.65), cognitive problems/inattention (mean = 59, SD = 12.04), hyperactivity (mean = 61, SD = 15.23), and ADHD index (mean = 60, SD = 12.59). Individual subjects' T-scores for the CPRS-R:S were compared to a mean value of 50 using a one-sample *t* test (see Table 1) with a Bonferroni adjustment to account for administering multiple statistical tests (.05/4 = .0125). The one-sample *t* tests for the CPRS-R:S showed that cognitive problems/inattention, hyperactivity, and ADHD index categories were significantly higher than a mean of 50 ($p \leq 0.001$ for all tests; see Figures 1-3). For the oppositional category, the mean score of 54 was not significantly dif-

Table 1. Scores for the CPRS-R:S

| Category | Mean T score (SD) | one-sample t test |
|--------------------------------|-------------------|-------------------|
| Oppositional | 54 (9.65) | ≤ 0.036 |
| Cognitive problems/inattention | 59 (12.04) | $\leq 0.001^*$ |
| Hyperactivity | 61 (15.23) | $\leq 0.001^*$ |
| ADHD index | 60 (12.59) | $\leq 0.001^*$ |

* $p < 0.01$ (when making Bonferonni adjustment for multiple tests).

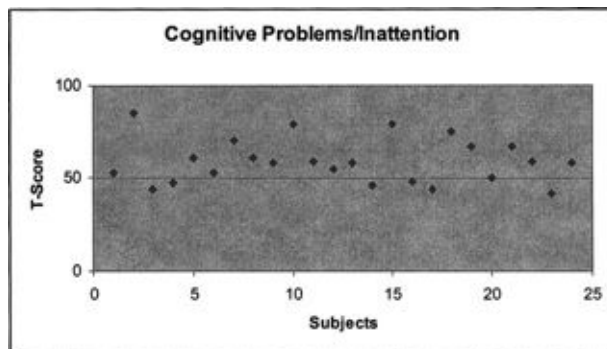


Figure 1 Scatterplot of T-scores for each subject for cognitive problems/inattention category. Individual T-scores are compared with a mean value of 50.

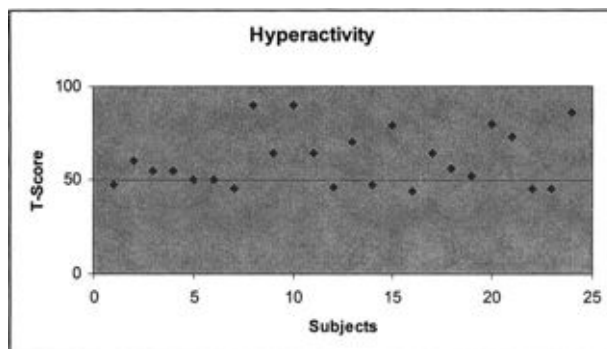


Figure 2 Scatterplot of T-scores for each subject for hyperactivity category. Individual T-scores are compared with a mean value of 50.

ferent from a mean value of 50 when using a Bonferroni adjustment. Thus, 3 of the 4 categories in the CPRS-R:S were significantly higher than normative values for children with accommodative dysfunction or CI.

Discussion

The results from this preliminary study suggest that school-aged children with symptomatic accommodative dysfunction or CI have a higher

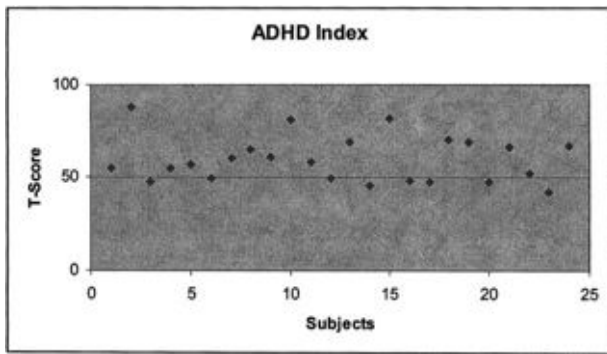


Figure 3 Scatterplot of T-scores for each subject for ADHD index. Individual T-scores are compared with a mean value of 50.

frequency of behaviors related to school performance and attention as measured by the CPRS-R:S. This study replicated results from our previous study that found that children with CI scored higher on the CPRS.⁷ We were able to show that the association between vision problems and ADHD was still maintained when we added children with symptomatic accommodative dysfunction to our sample and when using the CPRS-R:S. However, our results should be viewed cautiously until the finding is replicated on a larger sample of children.

We also evaluated the clinical relevance of the scores on the CPRS-R:S for the accommodative dysfunction and CI group compared with mean values. Connors recommends that a change of one half of an SD or 5 T-score units is clinically significant.³ This change is also outside of most of the subtests' 95% confidence intervals that we calculated from Table 7.22 in the manual. We could only estimate the 95% confidence intervals based on converting the standard errors of measurement, which are given in raw scores, to average T-score values. Thus, our symptomatic accommodative dysfunction or CI group scores of 8 standard score units or higher than mean values on the cognitive problems/inattention, hyperactivity, and ADHD scales would be considered clinically significant.

Children with symptomatic accommodative dysfunction or CI appear to have a higher frequency of ADHD-like behaviors as measured by the CPRS-R:S. One explanation is that accommodative dysfunction or CI may cause behaviors similar to those seen in ADHD, especially the inattentive subtype.² This would be consistent with the hypothesis put forth by Farrar et al.⁶ and Damari et al.⁵ Some of the symptoms on the

CISS-V15, such as loss of concentration when reading or reading slowly, are similar to behaviors associated with ADHD (inattentive type), such as failure to complete assignments and trouble concentrating in class.^{2,3} However, this explanation does not account for the increase in the hyperactivity scale in the symptomatic accommodative dysfunction or CI group. In this study, we did not have a large enough sample size to correlate the symptoms between the CISS-V15 and the CPRS-R:S to more directly test this hypothesis. In the future, we hope to look at this hypothesis in more detail.

Another possible mechanism that would explain the association between accommodative dysfunction or CI and ADHD behaviors is that accommodative dysfunction and CI are manifestations of immaturities in the visuomotor, spatial, and attention processing mechanisms. For example, Atkinson¹⁴ found that children with neurological disorders have poorer shifts of accommodation to near targets. Yang et al.¹⁵ found more variability in the latency of combined vergence and saccadic responses in children when compared with adults. Yang et al.¹⁵ hypothesized that increased variability could represent immaturity in the control of visual fixation, which is part of the visuomotor spatial and attention processes. Evidence for problems in visuomotor, spatial, and attention processing has also been found when measuring saccadic ability in children with ADHD.¹⁶ Children with symptomatic accommodative dysfunction or CI may be more at risk for problems in processing information using the visual attention system, which may result in poorer control in the accommodative or vergence mechanisms. That is, findings of a receded near point of convergence or poor positive fusional vergence may result from problems with variable latencies and fixation control within the oculomotor system. Thus, children with accommodative dysfunction or CI may have poorly developed attention mechanisms in the central nervous system that result in both poor coordination of the oculomotor system and manifestation of behaviors seen in ADHD. We hope that future research will replicate our findings and begin to determine the exact associations between accommodative dysfunction or CI and visual attention.

This preliminary study found that children with symptomatic accommodative dysfunction or CI

have a higher frequency of behaviors associated with ADHD and learning problems as measured by the CPRS-R:S.

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