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Academic Behaviors in Children with Convergence Insufficiency with and without Parent-Reported ADHD

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Abstract

Purpose—To determine if children with symptomatic Convergence Insufficiency (CI) without the presence of parent reported Attention Deficit Hyperactivity Disorder (ADHD) have higher scores on the academic behavior survey (ABS).

Methods—The Academic Behavior Survey (ABS) is a 6-item survey that evaluates parent concern about school performance and the parents' perceptions of the frequency of problem behaviors that their child may exhibit when reading or performing schoolwork (such as: difficulty completing work, avoidance, and inattention). Each item is scored on an ordinal scale from 0 (Never) to 4 (Always) with a total score ranging from 0 to 24. The survey was administered to the parents of 212 children 9-17 years old (mean age 11.8 yrs.) with symptomatic CI prior to enrolling into the Convergence Insufficiency Treatment Trial and to 49 children with normal binocular vision (NBV) (mean age 12.5 years). The parents reported whether the child had ADHD and this information was used to divide

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the symptomatic CI group into the CI with parent-report of ADHD or CI with parent-report of no ADHD groups.

Results—Sixteen percent of the CI group and 6% of the NBV group were classified as ADHD by parental report. An analysis of covariance showed that the total ABS score for the symptomatic CI with parent-report of ADHD group (15.6) was significantly higher than the symptomatic CI with parent-report of no ADHD group (11.7, p=0.001) and the NBV group (8.7, p<0.0001). Children with CI with parent-report of no ADHD scored significantly higher on the ABS than the NBV group (p=0.036).

Conclusions—Children with symptomatic CI with parent-report of no ADHD scored higher on the ABS when compared to children with NBV. Children with parent-report of ADHD or related learning problems may benefit from comprehensive vision evaluation to assess for the presence of CI.

Keywords

convergence insufficiency; attention deficit hyperactivity disorder; reading; symptoms; parent perception; school work performance

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Convergence insufficiency (CI) is a common vision disorder characterized by exophoria greater at near than at distance, a receded near point of convergence, and reduced positive fusional vergence at near and has a prevalence of approximately 5%.[1-4] The adverse impact of CI occurs during near viewing where typical symptoms include; double vision, blurred vision, eye strain, difficulty concentrating, and slow reading.[1, 5-9] Recently, child-reported symptoms associated with CI have been quantified using the convergence insufficiency symptom survey (CISS).[1, 6] The CISS allows a two-factor analysis of symptoms; first, whether the symptom is present and second, how frequently the symptom occurs. The CISS has been shown to discriminate between children with CI and children with normal binocular vision (NBV) in clinical and population based settings.[1, 5, 6] In addition, children with 3 signs of CI have been able to provide reliable responses to the survey questions on the CISS.[6]

In contrast to symptom reporting in children, the parent reports of their child's symptoms associated with CI have not been studied as thoroughly. Only one study has looked at agreement between parent and child reporting on the CISS and found that the parent and child tended to agree on whether the child was symptomatic or asymptomatic, although the total scores did not agree.[5] Investigating the parent reports of observable behaviors related to school work in children with symptomatic CI becomes especially important due to recent studies that have suggested a possible association between CI and a prevalent behavioral disorder, Attention Deficit Hyperactivity Disorder (ADHD).[10-12] Borsting et al[10] argued that the symptoms frequently reported in CI 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.[13, 14] One criticism of the Borsting et al study is that in a study with a relatively small sample size, the CI group could have included children with ADHD which may have in turn biased the parent towards reporting a higher frequency of behaviors. As a result, it would be of interest to determine if symptomatic CI children without reported ADHD had a significantly greater frequency of behaviors that may interfere with academic work.

Therefore, the purpose of this study was to determine if children with symptomatic Convergence Insufficiency (CI) without the presence of parent reported Attention Deficit Hyperactivity Disorder (ADHD) have higher scores on our newly developed parent survey, the academic behavior survey (ABS) as reported by the parent. Thus, we compared parent self-reported responses on the ABS in children who have symptomatic CI with parent-report of

ADHD, symptomatic CI with parent-report of no ADHD, and children with normal binocular vision (NBV) and parent-report of no ADHD.

Patient and Methods

Survey Development

An expert clinician approach was used for developing the ABS, based on a previous study that asked parents questions similar to those on the CISS along with items about short attention span and avoidance of near work.5, 15 This study indicated that parents of children with CI more frequently reported attention span problems and fails to finish things more than the NBV group.5 Investigating academic related behaviors was a secondary outcome of the Convergence Insufficiency Treatment Trial (CITT) which evaluated different treatment modes for remediating CI. Both the Data Safety and Monitoring Committee and the Executive Committee decided that a brief survey that asked a few questions was the most appropriate method to probe this issue in children with CI, instead of using lengthy standardized surveys of children's behavior. We developed questions that addressed behaviors that a parent could easily observe such as avoiding near work and problems with completing school work. In addition we included one question regarding the parent's level of concern about school performance. Previous research has found that parent and child agreement is better when items are easily observable (such as walking up and down stairs) are used, as opposed to, reporting on somatic issues (such as amount of pain) which are more subjective.16¯18 A list of potential questions was generated and field tested by the CITT Executive Committee along with select members of the CITT investigators research team. Based on this feedback, the final six questions were developed with each item scored on an ordinal scale from 0 (Never) to 4 (Always) as used in the CISS, with a range of possible scores from 0 to 24.6, 19 (Figure 1)

Subject Selection

The study was supported through a cooperative agreement with the National Eye Institute of the National Institutes of Health (NCT00338611) and conducted by the CITT Group at 9 clinical sites (see appendix). The respective institutional review boards approved the protocol and HIPAA-compliant informed consent forms. The parent or legal guardian of each study subject gave written informed consent and written assent was obtained from each child. Study oversight was provided by an independent data and safety monitoring committee appointed by National Eye Institute.

Children ages 9 to 17 inclusive with symptomatic CI were recruited to meet the inclusion and exclusion criteria for the CITT at participating centers.[20] The NBV subjects were recruited in a similar manner at six of the nine CITT study sites as part of an ancillary study (see appendix). The NBV children had the same exclusion criteria as the CITT and the inclusion criteria are listed in Table 1. In order to assess eligibility both the CI and NBV subjects received the same testing to evaluate binocular vision and accommodative ability.

Procedures

The ABS was completed by the parent or guardian present at the eligibility examination of children with symptomatic CI or NBV. The parent was given the ABS as the last document in a series of documents that recorded demographic information, medication information and health history. The following instructions were included on the ABS form: Please rate each item according to your child's behavior during the last school month. If your child was not in school last month, think about during the last month he/ she was in school. For each item, ask yourself “How much of a problem has this been in the last month?” and check the best answer for each one. Please respond to all 6 items. The parent was not allowed to consult with the child during the completion of the survey. Prior to filling out the ABS, parents or guardians were

asked the following question to identify the presence or absence of ADHD as part of the demographic information: “Has a doctor ever told you that your child has Attention Deficient/ Hyperactivity Disorder (ADHD) or Attention Deficient Disorder (ADD)?”

Data Analysis

Survey—The ABS is scored on an ordinal scale from 0 (Never) to 4 (Always), with a range of possible scores from 0 to 24. (Figure 1) In order to determine if it was appropriate to use the simple sum of the six items on the ABS as a measure of academic behavior, two separate analyses were performed. In the first analysis, the internal consistency of the responses on the ABS was assessed using the Cronbach's Alpha. This analysis suggested excellent consistency with a value of 0.92 for the six-item survey. The removal of any individual item did not improve the internal consistency of the survey. Next, a principal components analysis was used to examine the effect of using a different weighting scheme when determining the ABS score. This analysis offers a method of summarizing the data by developing a linear combination of the six items of the ABS which maximizes the variability explained (i.e. the 1st principal component). For these data, the 1st principal component explained 71% of the variability in responses and was, in fact, the only factor with an eigenvalue greater than 1. To test the robustness of our findings, all comparisons of the ABS score between groups were repeated using the weighting scheme of the 1st principal component. The findings were identical to those reported herein.

Comparison of the mean score on the ABS between the three patient groups was performed using an Analysis of Covariance (ANCOVA). Given the non-random nature of the data, it was important to identify factors that may serve as confounders to the true relationship between study group and ABS. By definition, a factor is classified as a potential confounder if it is related to both ABS score and study group. As a first step in identifying these confounders, analysis of variance and chi-square tests were used to compare the three patient groups with respect to demographic and clinical variables. Analysis of variance and Pearson correlations were used to assess the relationship between ABS score and each demographic and clinical variable. Variables found to be significantly different across study groups and related to ABS score were included in initial ANCOVA models containing study group one at a time. If these variables remained significant in the ANCOVA model ($p < 0.05$), they were retained for inclusion in the final ANCOVA model assessing the relationship between study group and ABS score.

The distribution of responses for each of the 6 items of the ABS was compared between groups using a Kruskall-Wallis test. When assessing the results of the Kruskall-Wallis test, a Bonferroni adjustment (alpha = 0.05/6 = 0.0083) was made to adjust for the multiple statistical tests performed. Post-hoc pair-wise comparisons were performed using the Wilcoxon rank sum test.

Results

The survey was administered to the parents or guardians of 221 children with symptomatic CI (mean age 11.8 years) prior to enrollment into the Convergence Insufficiency Treatment Trial and to the parents of 49 children with NBV (mean age 12.5 years) as part of an ancillary study. The ADHD status was not recorded for nine children with CI and they were excluded from the subsequent analysis. In the CI group, parents or guardians of 34 (16%) children responded positively to the question about the diagnosis of ADHD by a medical professional. Of the CI children with parent-report of ADHD, 19 (56%) were on psychotropic medications whereas only 2 children in the parent-report of no ADHD group were taking psychotropic medications. In the NBV group, 3 (6%) responded positively to the presence of ADHD. A chi-square test showed only a trend in the percentage of parent-report ADHD in the CI compared to the NBV

groups (16% vs. 6%; chi-square = 3.22, p = 0.073). The two CI children with parent-report of no ADHD but psychotropic medication use and the three NBV children with ADHD were excluded from all further analyses (see table 2 for number of subjects in each group)

Descriptive statistics for demographic and clinical measures by study group are listed in Table 3. Significantly fewer children in the NBV group reported Hispanic or Latino ethnicity compared to either of the CI groups (p = 0.019). This is most likely due to CITT site participation in the ancillary study because some study sites, that had enrolled a significant number of Hispanic or Latino children in the CITT, chose not to participate in the NBV ancillary study. There was a significant difference in the level of refractive error observed across the three-study groups (p = 0.016). Children enrolled in the NBV study were slightly more myopic (mean = -0.75D) when compared to the children with symptomatic CI with parent-report of no ADHD (mean = -0.06D, p = 0.020). There was also a marginally significant difference between the NBV study group and the symptomatic CI with parent-report of ADHD group (mean = +0.09D, p = 0.045). No difference was observed between the two CI groups (p = 0.87).

Significant differences between the CI and NBV groups with respect to clinical signs of CI (such as near point of convergence, positive fusional vergence, and phoria) and the CISS were a by-product of the inclusion/exclusion criteria used to identify the CI and NBV subjects. In addition, there was a significantly higher CISS score in CI children with parent-report of ADHD compared to their counterparts with parent-report of no ADHD (p = 0.012).

Refractive error and CISS score were the only variables from Table 2 included in the final ANCOVA model comparing the mean ABS score between the three patient groups. In this model, hyperopic increases in refractive error were associated with increases in the ABS score (beta = 0.47, p = 0.040). Similarly, higher level of symptoms were associated with higher ABS scores (beta = 0.16, p < 0.0001). The adjusted mean ABS score among children with NBV was 8.7 points (95% confidence interval (CI) = 6.6, 10.8), which was significantly lower than the ABS score for either the symptomatic CI with parent-report of ADHD or symptomatic CI with parent-report of no ADHD groups (p < 0.0001 and p = 0.036 respectively). Among children who had CI with parent-report of no ADHD the mean ABS was 11.7 points (95% CI = 10.9, 12.6) and the mean for the symptomatic CI with parent-report of ADHD was 15.6 points (95% CI = 13.6, 17.5). There was also a significant difference in the scores observed in the two CI groups (p = 0.001).

As shown on Figures 2 through 7, the distribution of responses on each of the six survey items differed between the three patient groups (p < 0.0001 for each comparison). After controlling for multiple comparisons, the scores for five of the six items of the ABS were higher in the symptomatic CI with parent-report of ADHD group when compared to the symptomatic CI with parent-report of no ADHD group. After controlling for multiple comparisons, only the parent's worry about their child's performance was not significantly higher in the symptomatic CI with parent-report of ADHD group (p = 0.019). When comparing both CI groups to the NBV group significant differences were seen for children with parent-report of no ADHD, as well as those children with parent-report of ADHD (p < 0.001 for all comparisons).

Discussion

Our results indicate that children with symptomatic CI with parent-report of ADHD scored higher on the ABS when compared to children who had symptomatic CI with parent-report of no ADHD and that both CI groups scored significantly higher on the ABS survey when compared to children with NBV. These results are consistent with previous studies that have assessed symptoms in children with the CISS.[1, 6] Thus, both children with symptomatic CI

and their parents report a significantly higher number of academic performance symptoms as compared to children with NBV.

The results of this study indicate that the presence of CI was associated with higher scores on the ABS even after accounting for child's initial symptom level on the CISS in a large of sample of symptomatic CI children. This addresses one of the criticisms of our previous studies that reported similar findings with much smaller sample sizes. The CI with parent report of no ADHD group scored three points higher on the ABS than the NBV group. The question arises as to the clinical significance of the statistically significant result. Although the ABS is a newer clinical instrument we can still investigate the effect size of the difference between the groups. A three point change translates into an effect size of 0.5. According to Cohen[21] this effect would be classified as medium (0.5).

One limitation of our study is that we did not include a group of NBV children with parent report of ADHD. It would be of interest to determine if children with NBV with parent report of ADHD would score higher on the ABS when compared to the other 3 groups. A study with all four groups could provide further information about the relative contributions of CI and ADHD to scores on the ABS as well as the CISS. Another limitation of the this study was that our sample represented a pre-selected group of symptomatic CI children with 3-signs of CI.[20] Our results may not apply to children who have normal scores ($\leq$ 16) on the CISS or who have milder cases of CI that do not exhibit all three clinical signs.

Given that symptomatic CI children have symptoms and behaviors similar to children with ADHD, it would be of interest to determine if the prevalence of CI is higher in an ADHD population. Some preliminary studies have suggested this possibility. Granet et al11 found a higher prevalence of ADHD in children diagnosed with CI when conducting a retrospective review of charts. Gronlund et al11, [12] (2007) found one sign of CI (abnormal NPC) in 24% of the ADHD group but only 6% of the reference group. Due to the small number of NBV children with ADHD in our sample it is difficult for our study to answer this question but this issue should be investigated in an ADHD sample.

There are several sources of bias that potentially exist in our study. The higher scores in the symptomatic CI with parent-report of ADHD group could be attributed to parent bias when filling out the ABS. Parents, who self reported ADHD, may have interpreted the items on the ABS as similar to ADHD and in turn ranked the child higher on this survey. This potential source of bias was mitigated, in part, by titling the survey as the Academic Behavior Survey. Examiner bias was kept to a minimum by masking the examiner to the parent's response to the question about the presence of ADHD and having the parent fill out the survey by themselves, without verbal instructions from the examiner. The parents also reported an increase frequency of worry in both the CI with no parent report of ADHD and in the CI with parent report of ADHD when compared to the NBV group. It would be likely for the parent to report an increase frequency of worry due to the bias that parents pursue eye care because he or she feels that the child has a significant problem. However, both the CI and NBV group were recruited in a similar manner from clinic populations at each site. Children with higher symptom level on the CISS could have biased the parent to report a higher frequency of behaviors on the ABS. This potential bias was controlled for by using the CISS as a covariate in our analysis.

Another source of bias was that we relied on parental report for the presence of ADHD and we did not confirm that a diagnosis had been made by a qualified professional. This could lead to two sources of bias. First, although we specifically asked if a doctor had told the parent that the child had ADHD, it is possible that some parents reported ADHD that had not been diagnosed by a qualified professional. The National Survey of Children's Health conducted in 2003 used a telephone survey and asked similar questions about ADHD to our study.[22] A

subsequent analysis of the data showed that parental report of ADHD was 9.7% among children ages 9 to 17 and medication usage was 64% in the 9-12 age group and was 47% in the 13-17 age group.[23] The reported prevalence of ADHD in our CI group of 15.4% and the parental report of medication usage of 56% was similar to the data from the National Survey of Children's Health for the 9-17 age range. Our distribution of parent reported ADHD is quite similar to that reported in a large population based study. Second, our CI with parent-report of no ADHD group could have included children with undiagnosed ADHD. Without a medical evaluation for ADHD for all of the subjects, it is not possible to know definitively that each group was composed of only one classification or the other. However, given the large number of CI children in this group it is unlikely that the presence of a few subjects with undiagnosed ADHD would have altered the results.

In conclusion, the presence of CI contributes to the parents' reports of difficulty with their child's ability to complete schoolwork efficiently. In addition, parents of children with CI reportedly “worry” more about their children's school performance than parents of children with NBV. Children with parent-reported ADHD or related learning problems may benefit from comprehensive vision evaluation to assess for the presence of CI beyond a typical vision screening which targets the detection of strabismus, amblyopia, and significant refractive error.

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The Convergence Insufficiency Treatment Trial Investigator Group

Clinical Sites

Sites are listed in order of the number of patients enrolled in the study with the number of NBV patients enrolled listed in parentheses preceded by the site name and location. Personnel are listed as (PI) for principal investigator, (SC) for coordinator, (E) for examiner, and (VT) for therapist.

Study Center: SUNY College of Optometry (8 NBV, 28 CI)

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Study Center: Bascom Palmer Eye Institute (35 CI)

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Study Center: NOVA Southeastern University (8 NBV, 27 CI)

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Study Center: UAB School of Optometry (7 NBV, 28 CI)

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Study Center: Pennsylvania College of Optometry (9 NBV, 25 CI)

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Study Center - The Ohio State University College of Optometry (8 NBV, 24 CI)

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Study Center: Southern California College of Optometry (9 NBV, 23 CI)

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Study Center: University of CA San Diego: Ratner Children's Eye Center (17 CI)

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Study Center: Mayo Clinic (14 CI)

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		Never	Infrequently	Sometimes	Fairly often	Always
1.	How often does your child have difficulty completing assignments at school?					
2.	How often does your child have difficulty completing homework?					
3.	How often does your child avoid or say he/she does not want to do tasks that require reading or close work?					
4.	How often does your child fail to give attention to details or make careless mistakes in schoolwork or homework?					
5.	How often does your child appear inattentive or easily distracted during reading or close work?					
6.	How often do you worry about your child's school performance?					

Figure 1.
The Academic Behavior Survey.

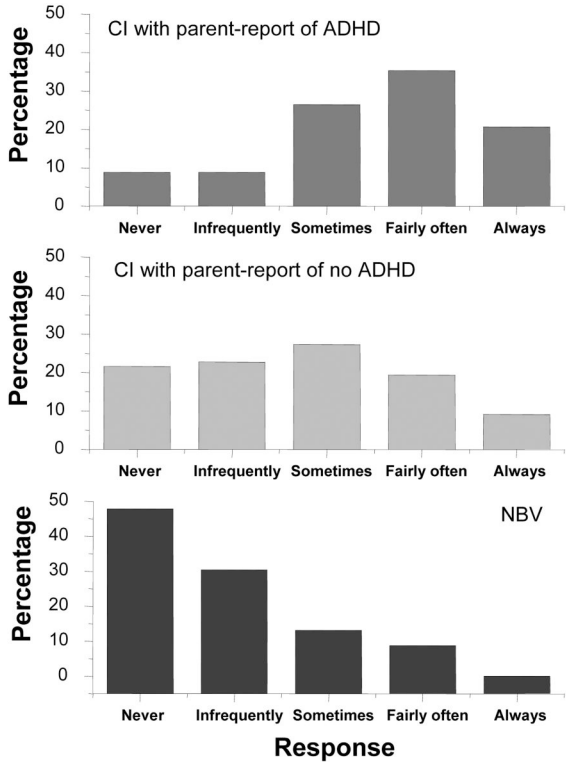

Figure 2.

The percentage of parents responding to each category on the ABS for the CI children with parent-report ADHD, CI with parent-report of no ADHD, and NBV groups for question 1: How often does your child have difficulty completing assignments at school?

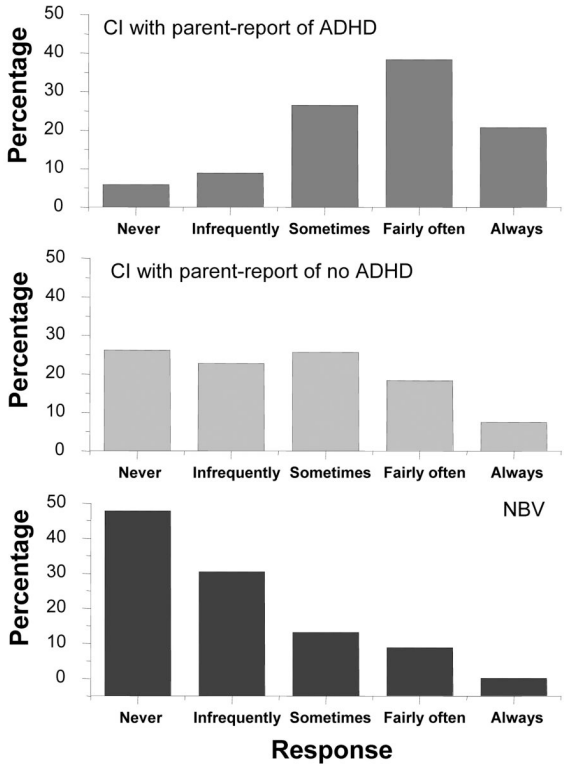

Figure 3.
The percentage of parents responding to each category on the ABS for the CI children with parent-report ADHD, CI with parent-report of no ADHD, and NBV groups for question 2: How often does your child have difficulty completing homework?

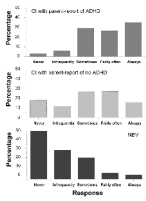

Figure 4.
The percentage of parents responding to each category on the ABS for the CI children with parent-report ADHD, CI with parent-report of no ADHD, and NBV groups for question 3: How often does your child avoid or say he/she does not want to do tasks that require reading or close work?

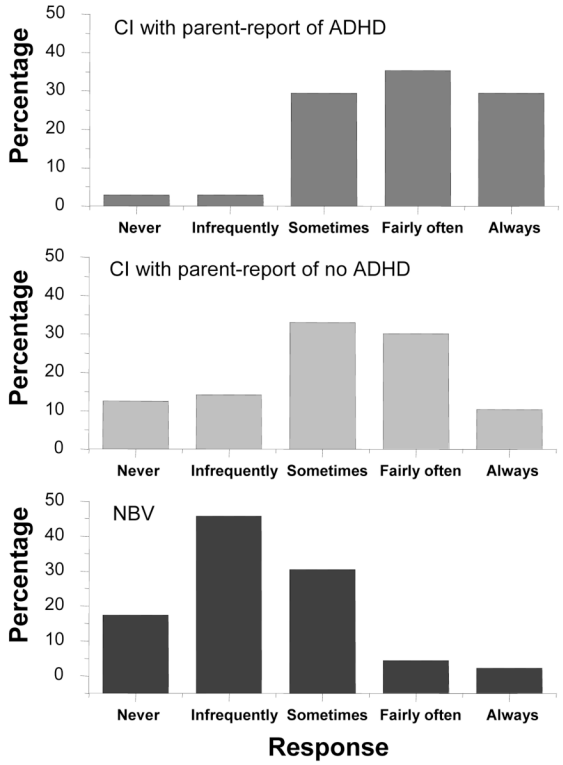

Figure 5.
The percentage of parents responding to each category on the ABS for the CI children with parent-report ADHD, CI with parent-report of no ADHD, and NBV groups for question 4: How often does your child fail to give attention to details or make careless mistakes in schoolwork or homework?

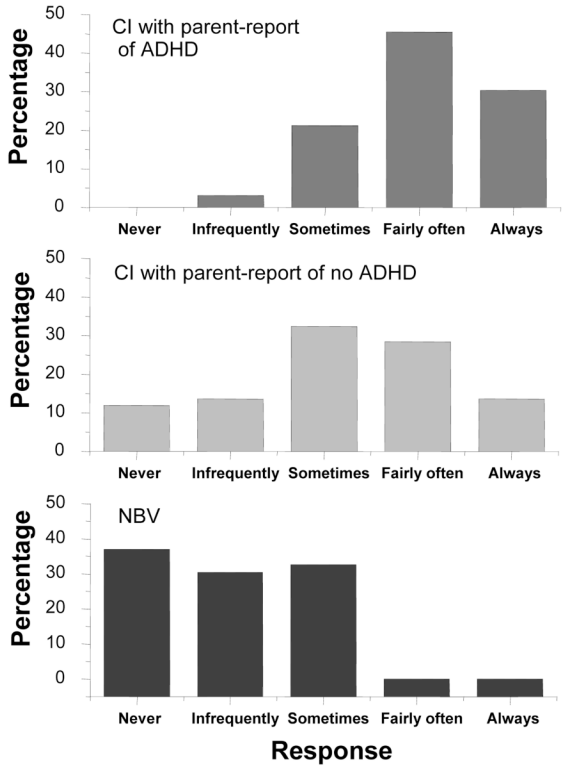

Figure 6.
The percentage of parents responding to each category on the ABS for the CI children with parent-report ADHD, CI with parent-report of no ADHD, and NBV groups for question 5: How often does your child appear inattentive or easily distracted during reading or close work?

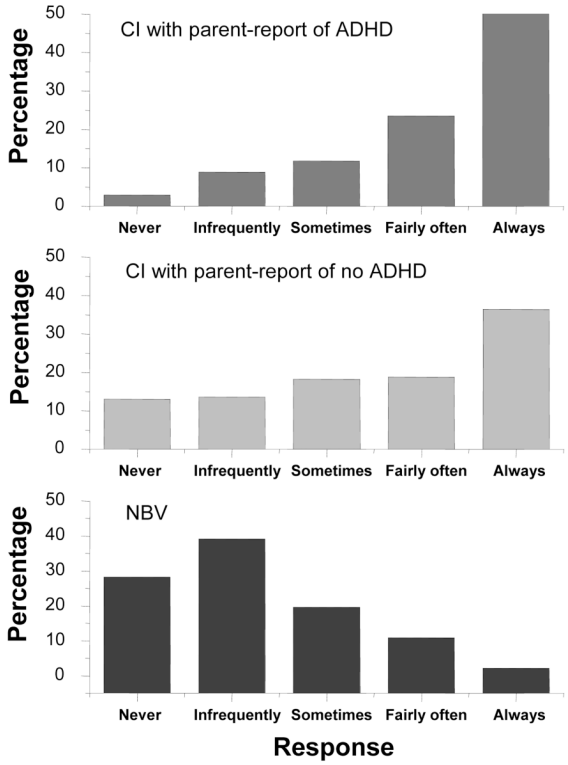

Figure 7.
The percentage of parents responding to each category on the ABS for the CI children with parent-report ADHD, CI with parent-report of no ADHD, and NBV groups for question 6: How often do you worry about your child's school performance?

Table 1

Inclusion Criteria for NBV subjects.

a. Age 9 to < 18 years
b. Sex: either
c. Ethnicity: any
d. Best corrected visual acuity of 20/25 or better in both eyes at distance and near
e. Appropriate refractive correction worn for at least 2 weeks (see below)
f. Heterophoria at near between 2Δ esophoria and 8Δ exophoria
g. Negative fusional vergence at near (greater than 7Δ BI-break/5Δ BI-recovery)
h. Positive fusional vergence at near (greater than 10Δ BO-break/7Δ BO-recovery)
i. NPC closer than 6.0 cm break
j. Monocular amplitude of accommodation (greater than 15-0.25*age)
k. Appreciation of random dot stereopsis using a 500 seconds of arc target
l. Had cycloplegia refraction within past 2 months
m. Informed consent and willingness to participate in the study

Table 2

Number of subjects in each group.

CI with no parent report of ADHD	CI with parent report of ADHD	NBV with no parent report of ADHD	NBV with parent report of ADHD (sample excluded from data analysis)
N=176	N=34	N=46	N=3

Table 3

Summary statistics for clinical and demographic measures at the enrollment visit, by study group.

Characteristic	CI group		NBV	p-value
	w/o ADHD (n=176)	w/ADHD (n=34)	group (n=46)	
Mean (std) age in years	11.8 (2.4)	12.1 (2.2)	12.5 (2.4)	0.15
% Female	59.1	50.0	60.9	0.57
Mean (std) Near Point of Convergence (cm)				
Break	14.4 (7.3)	13.4 (8.9)	3.5 (1.2)	<0.0001
Recovery	18.1 (7.7)	17.5 (10.5)	5.2 (1.6)	<0.0001
Mean (std) Positive Fusional Vergence (Δ)				
Blur/Break	10.9 (4.0)	11.7 (3.4)	24.0 (10.2)	<0.0001
Recovery	8.9 (4.5)	9.3 (4.6)	22.1 (7.7)	<0.0001
Mean (std) Phoria (Δ)				
At Near	9.1 exo (4.3)	8.8 exo (4.0)	2.1 exo (2.3)	<0.0001
At Distance	1.9 exo (2.7)	1.3 exo (2.2)	0.6 exo (1.3)	0.005
% Intermittent exotropia				
At near	9.7	2.9	0.0	0.045
At distance	2.3	0.0	0.0	0.40
% failed Sheard's criterion	82.4	76.5	2.2	<0.0001
CISS Score	29.5 (8.7)	34.1 (8.6)	10.4 (8.1)	<0.0001
Race				0.057
% American Indian/Alaskan Native	4.6	6.1	0.0	
% Asian/Pacific Islander	2.3	0.0	2.2	
% Black or African American	30.9	24.2	45.7	
% White	53.1	63.6	32.6	
% Other	9.1	6.1	19.6	
% Hispanic or Latino	34.1	26.5	13.0	0.019
Mean (std) Accommodative Amplitude (D)	9.8 (3.8)	10.2 (4.2)	16.2 (4.1)	<0.0001
% with Accommodative Insufficiency	56.8	52.9	0.0	<0.0001
Mean (std) Accommodative Facility (cycles)	6.5 (4.3)	5.6 (4.9)	8.9 (5.8)	0.003
% 20/20 or better visual acuity at near	79.6	82.4	100.0	0.004
% 20/20 or better visual acuity at distance	88.6	91.2	89.1	0.91
Mean (std) Spherical Equivalent – OD (D)	-0.06 (1.4)	0.09 (1.7)	-0.75 (2.0)	0.016
Refractive error category – Right eye				0.013

Characteristic	CI group		NBV	p-value
	w/o ADHD (n=176)	w/ADHD (n=34)	group (n=46)	
% Myopic (nearsighted)	22.2	17.7	30.4	
% Hyperopic (farsighted)	7.4	20.6	0.0	
% Emmetropic (normal)	70.4	61.8	69.6	
% children wearing correction	33.0	35.3	37.0	0.87