Journal of Attention Disorders
XX(X) 1–9
© 2013 SAGE Publications
Reprints and permissions:
sagepub.com/journalsPermissions.nav
DOI: 10.1177/1087054713511528
jad.sagepub.com
SAGE

Behavioral and Emotional Problems Associated With Convergence Insufficiency in Children: An Open Trial

Eric Borsting[1], G. Lynn Mitchell[2], L. Eugene Arnold[2], Mitchell Scheiman[3], Christopher Chase[4], Marjean Kulp[2], Susan Cotter[1], and CITT-RS Group[5]

Abstract

Objective: This study investigated behavioral and emotional characteristics of children with convergence insufficiency (CI), before and after treatment with office-based vergence accommodative therapy (OBVAT). **Method:** Parents of 44 children ages 9 to 17 years with symptomatic CI completed the Conners 3 ADHD Index and the Child Behavior Checklist (CBCL) before and after OBVAT. Pre-treatment scores were compared with normative data and post-treatment scores were compared with baseline using the Wilcoxon sign rank test. **Results:** Following OBVAT, CI children showed a significant mean improvement ($p < .0001$, effect size of 0.58) on the Conners 3 ADHD Index with the largest changes occurring in the 23 children who scored the highest at baseline. On the CBCL, anxious/depressed, somatic, and internalizing problems improved significantly ($p < .001$, effect sizes of −0.36, −1.15, and −0.67, respectively). **Conclusion:** In an open trial, attention and internalizing problems improved significantly following treatment for CI. *(J. of Att. Dis. XXXX; XX(X) XX-XX)*

Keywords

ADHD, symptomatology, sustained attention, convergence insufficiency, vergence

Convergence insufficiency (CI) is a vision disorder that affects approximately 5% of school-aged children and is associated with symptoms and impairments when reading or doing close work.(Borsting, Rouse, Deland, et al., 2003; Borsting, Rouse, Mitchell, et al., 2003; Letourneau & Ducic, 1988; Letourneau, Lapierre, & Lamont, 1979; Rouse et al., 1999; Rouse, Borsting, Mitchell, Cotter, et al., 2009; Rouse, Borsting, Mitchell, Kulp, et al., 2009). Children with CI self-report more somatic (e.g., eyes hurt and headaches), visual (e.g., blur and diplopia), and performance (e.g., loss of concentration, frequent need to re-read, and difficulty remembering what is read) problems compared with children with normal vision (Borsting, Rouse, Mitchell, et al., 2003; Rouse, Borsting, Mitchell, Cotter, et al., 2009). In addition, parents of children with CI have reported a significantly greater level of adverse academic behaviors and worry about school performance when compared with children with normal binocular vision (Rouse, Borsting, Mitchell, Kulp, et al., 2009). The specific adverse academic behaviors reported by parents include difficulty completing schoolwork, avoidance of reading and studying, and inattentiveness during reading.

Recent randomized clinical trials have found that office-based vergence accommodative therapy (OBVAT) is the most effective treatment for reducing somatic, visual, and performance based symptoms and improving clinical signs of CI in children when compared with sham and home-based treatments (Barnhardt et al., 2012; Convergence Insufficiency Treatment Trial [CITT] Study Group, 2008b; Scheiman, Mitchell, Cotter, Cooper, et al., 2005). In addition, improved and successful outcomes after treatment for symptomatic CI in school-aged children were associated with an overall reduction in the frequency of adverse academic behaviors and parental concern associated with reading and schoolwork (Borsting et al., 2012).

Parental report of adverse behaviors related to schoolwork in children with symptomatic CI could have potential implications for the diagnosis of disorders that rely on parent observations of children's behaviors or emotional problems. For example, recent studies have suggested a possible relationship between CI and ADHD (Borsting, Rouse, & Chu, 2005; Granet, Gomi, Ventura, & Miller-Scholte, 2005;

[1]Marshall B. Ketchum University, Fullerton, CA, USA
[2]The Ohio State University, Columbus, USA
[3]Salus University, Philadelphia, PA, USA
[4]Western University of Health Sciences, Pomona, CA, USA
[5]Convergence Insufficiency Treatment Trial–Reading Study group

Corresponding Author:
Eric Borsting, Southern Californa College of Optometry at Marshall B. Ketchum University, 2575 Yorba Linda Blvd., Fullerton, CA 92831, USA.
Email: eborsting@ketchum.edu

Downloaded from jad.sagepub.com at PENNSYLVANIA STATE UNIV on May 10, 2016

Gronlund, Aring, Landgren, & Hellstrom, 2007; Rouse, Borsting, Mitchell, Kulp, et al., 2009). Borsting et al. (2005) noted that a number of symptoms frequently reported by children with CI (e.g., loss of concentration when reading or reading slowly) and by parents are similar to behaviors that are commonly reported in the inattentive type of ADHD (e.g., failure to complete assignments and trouble concentrating in class; American Psychiatric Association, 1994; Conners, 1997). In addition, a previous study found that children with CI scored higher than a visually normal group on a parent-reported somatic scale (Borsting, Rouse, Deland, & Convergence Insufficiency and Reading Study Group, 1999). These studies have assessed a limited range of behavioral and emotional problems in children with CI. However, the positive results would indicate the need for further investigation of a broader range of behavioral and emotional problems in children with this specific vision anomaly.

As an initial step to address this issue, we conducted a two-part study. First, we assessed a broad range of behavioral and emotional problems in children with CI. Next, we determined whether the successful treatment of CI was associated with a change in adverse behaviors and emotional problems.

Method

This was a multicenter study conducted by the Convergence Insufficiency Treatment Trial–Reading Study (CITT-RS) Group at seven clinical sites (see the appendix). The study investigated parental report of behavioral and emotional factors, along with academic performance in children with CI in preparation for conducting a large multicenter clinical trial investigating possible impact of improving CI on academic, behavioral, and emotional factors in school-aged children. The results of the academic assessment will be reported in a separate paper. This open trial was designed to gather data that would help with determining appropriate assessment tools and typical participant responses needed for a future clinical trial. The respective institutional review boards approved the protocol and Health Insurance Portability and Accountability Act (HIPAA)-compliant informed consent forms. The parent or legal guardian of each participant gave written informed consent, and written assent was obtained from each child.

Participants

Children and adolescents ages 9 to 17 years with symptomatic CI were recruited at participating CITT clinical centers. All children were screened for cognitive ability with the Kaufman Brief Intelligence Test–II, with an inclusion criteria of IQ > 80 (Kaufman & Kaufman, 2004). Additional eligibility criteria were proficiency in English and an absence of substance abuse (parental report). Children with a history of developmental disability that would interfere with the ability to obtain valid test results (examiner discretion) were excluded. See Table 1 for a comprehensive list of inclusion and exclusion criteria.

The diagnosis of CI was made following a comprehensive eye examination. Children with visual acuity of 20/25 or worse, significant uncorrected refractive error, and significant ocular pathology were excluded. The diagnostic criteria for CI were an exodeviation at near at least 4 prism diopters greater than at far, a receded near point of convergence (NPC) break (6 cm or greater), insufficient positive fusional vergence (PFV) at near (i.e., failing Sheard's criterion [PFV less than twice the near phoria; Sheard, 1930] or minimum PFV of ≤15Δ base-out blur or break), and a Convergence Insufficiency Symptom Score (CISS) of 16 or higher (CITT Study Group, 2008a, 2008b; Scheiman, Cotter, Rouse, Mitchell, et al., 2005; Scheiman, Mitchell, Cotter, Kulp, et al., 2005). The CISS is a 15-item survey that quantifies the frequency and severity of somatic, visual, and performance based symptoms using a 5-point scale of never (0), infrequently or just a little (1), sometimes (2), fairly often (3), or always (4) (Table 2; Borsting, Rouse, Deland, et al., 2003; CITT Study Group, 2008a, 2008b; Rouse, Borsting, Mitchell, Cotter, et al., 2009; Scheiman, Cotter, Rouse, Mitchell, et al., 2005; Scheiman, Mitchell, Cotter, Kulp, et al., 2005). Scores on the CISS range from 0 to 60. Two measures of accommodation, Donder's push-up and accommodative facility for the right eye, were also included in the evaluation because of the high association between CI and accommodative anomalies (Borsting, Rouse, Deland, et al., 2003; Rouse et al., 1999; Scheiman & Wick, 2002).

Procedures (Pre-Treatment: Comparison With Normal Scores)

Parental report of behavioral and emotional problems in children with CI was measured, prior to treatment, using the Conners 3 ADHD Index and the Child Behavior Checklist (CBCL). The Conners 3 ADHD Index and the CBCL were administered according to standard clinical administration procedures (Achenbach, 1991; Conners, 2009). The Conners 3 ADHD Index is a 10-item scale designed to identify children who are at increased risk of ADHD. A parent rates each behavior on a 4-point scale: not true at all (0), just a little true (1), pretty much true (2), and very much true (3).

The CBCL is a 120-item scale that assesses competencies, adaptive functioning, and behavioral, emotional, and social problems in children from 6 to 18 years of age. The respondents rate each behavior or symptom on a 3-point scale: not true (0), somewhat or sometimes true (1), or very true or often true (2). Results from the CBCL are divided into three competency scales (social, activities, and school),

Downloaded from jad.sagepub.com at PENNSYLVANIA STATE UNIV on May 10, 2016

Table 1. Eligibility and Exclusion Criteria for Children With Convergence Insufficiency (CI).

Inclusion criteria

1. Ages 9 to 17
2. IQ better than 80 (Kaufman Brief Intelligence Test–II)
3. Best corrected visual acuity of 20/25 or better in each eye at distance and near.
4. Exophoria at near at least 4Δ greater than at far.
5. Insufficient positive fusional convergence (i.e., failing Sheard's criterion or positive fusional vergence (PFV) < 15Δ base-out blur or break) Base-out to blur should be used if present otherwise use base-out to break.
6. Receded near point of convergence (NPC) of ≥ 6 cm break.
7. Appreciation of random dot stereopsis using a 500 seconds of arc target.
8. CI Symptom Survey score ≥ 16.
9. No previous CI treatment with office-based vergence accommodation therapy (OBVAT)
10. Willing to wear appropriate refractive correction for reading and other near activities
11. Willing to discontinue use of base-in prism, bifocals, or plus at near
12. Have access to a computer to perform the computerized home therapy procedures (HTS)
13. If new glasses or a change in prescription is necessary, the participant must be willing to wear the new glasses and return in 2 weeks for eligibility testing.
14. Must have had a cycloplegic refraction within the past 2 months.
15. English as the primary language spoken at home or proficient in English as determined by the school.

Exclusion criteria

1. ≥ 2Δ esophoria at distance
2. Significant hearing loss.
3. Substance abuser as indicated by a response of 2 on either Item 2 or Item 105 of the Child Behavior Checklist (CBCL).
4. A disability diagnosis in children that in the investigator's discretion would interfere with the testing and treatment regimen.
5. Amblyopia (≥ 2 line difference in best corrected visual acuity between the two eyes).
6. Constant strabismus.
7. History of strabismus surgery.
8. High Refractive Error based on cycloplegic refraction: Myopia ≥ 6.00D sphere, Hyperopia ≥ 5.00D sphere, Astigmatism ≥ 4.00D.
9. Anisometropia ≥ 2.0D spherical equivalent.
10. Prior refractive surgery.
11. Vertical heterophoria greater than 1Δ.
12. Systemic diseases known to affect accommodation, vergence, and ocular motility such as multiple sclerosis, Graves thyroid disease, myasthenia gravis, diabetes, and Parkinson's disease.
13. Accommodative amplitude greater than 20 cm in either eye as measured by Donder's push-up method.
14. Manifest or latent nystagmus.
15. CI secondary to acquired brain injury or any other neurological disorder.

eight empirically based symptom or problem scales (anxious/depressed, withdrawn/depressed, somatic complaints, social problems, thought problems, attention problems, rule breaking behavior, and aggressive behavior), and two global scores derived from the empirically based scales (internalizing and externalizing problems; Achenbach, 1991). The CBCL competency scales are scored such that lower scores indicate more problems whereas on the empirically based and global scales, higher scores indicate more problems.

Pre- to Post-Treatment

In the next part of the study, we determined whether changes in the behavioral and emotional problems occurred following treatment of CI. Children who completed the pre-treatment assessment were offered the option of enrolling in OBVAT for 16 weeks of treatment. This treatment involved weekly 60-min office visits that included specific therapy procedures to stimulate the vergence and accommodative systems. At each weekly visit, the patient performed four to five procedures with constant supervision and guidance from the therapist. There were no diagnostic tests performed during these sessions. The therapist followed a detailed and specific protocol from the CITT Manual of Procedures (accessed at http://optometry.osu.edu/research/CITT/4363.cfm); this document describes each procedure, amount of time used, expected performance, and criteria for ending the procedure and advancing to a more difficult level. At the end of each office visit, home reinforcement therapy was assigned for 15 min per day for 5 days a week and the child completed a home therapy log sheet to record how much therapy was completed.

Downloaded from jad.sagepub.com at PENNSYLVANIA STATE UNIV on May 10, 2016

Table 2. Convergence Insufficiency Symptom Survey (CISS).

	Never	Infrequently	Sometimes	Fairly often	Always
1. Do your eyes feel tired when reading or doing close work?	17.0	11.3	43.4	17.0	11.3
2. Do your eyes feel uncomfortable when reading or doing close work?	11.3	17.0	54.7	13.2	3.8
3. Do you have headaches when reading or doing close work?	22.6	20.8	32.1	17.0	7.6
4. Do you feel sleepy when reading or doing close work?	7.6	7.6	45.3	24.5	15.1
5. Do you lose concentration when reading or doing close work?	1.9	11.3	43.4	18.9	24.5
6. Do you have trouble remembering what you have read?	13.2	18.9	32.1	17.0	18.9
7. Do you have double vision when reading or doing close work?	28.3	20.8	32.1	9.4	9.4
8. Do you see the words move, jump, swim, or appear to float on the page when reading or doing close work?	45.3	18.9	17.0	13.2	5.7
9. Do you feel like you read slowly?	22.6	5.7	35.9	13.2	22.6
10. Do your eyes ever hurt when reading or doing close work?	18.9	26.4	37.7	9.4	7.6
11. Do your eyes ever feel sore when reading or doing close work?	35.9	22.6	26.4	9.4	5.7
12. Do you feel a "pulling" feeling around your eyes when reading or doing close work?	45.3	26.4	17.0	5.7	5.7
13. Do you notice the words blurring or coming in and out of focus when reading or doing close work?	15.1	9.4	43.4	17.0	15.1
14. Do you lose your place while reading or doing close work?	1.9	13.2	43.4	28.3	13.2
15. Do you have to re-read the same line of words when reading?	5.7	11.3	39.6	26.4	17.0

Note. Numbers in each cell are the percentage of responses at the pre-treatment visit.

After completing 16 weeks of OBVAT, children were prescribed a maintenance therapy program to be performed at home for 8 weeks before returning for a primary outcome visit at Week 24. This therapy consisted of one gross convergence technique and one vergence technique. We did not record the adherence to this phase of the home therapy treatment. A more detailed description of OBVAT and maintenance therapy has been published previously (CITT Study Group, 2008b).

At the end of maintenance therapy, the Conners 3 ADHD Index and the CBCL were completed by the parent of each child with CI. Enrollment windows were designed to insure that the child was attending school at the pre-treatment visit and had not been out of school for more than 2 weeks at the 24-week outcome visit.

Data Analysis

All analyses were performed using SAS Version 9.2 (Cary, North Carolina). To analyze the behavioral and emotional responses prior to treatment in children with CI, a Wilcoxon sign rank test (the non-parametric equivalent to a paired *t* test) was used to compare the mean of the Conners 3 ADHD Index and the scales of the CBCL to their published normative value. Raw scores for the Conners 3 ADHD Index and CBCL were converted to *z*-scores ($Z_i = (X_i - M)/SD$ for $i = 1$ to n with M and SD based on participant's age and gender) to express the deviation from the normative group in standard deviation units according to procedures recommended in the manual (Achenbach, 1991; Conners, 2009). Our analysis with *z*-scores used the same formula as Cohen's *d* for determining effect size and clinical significance (see below). In the text, we refer to this value as "*d*." To analyze the impact of treatment on behavioral and emotional status in children with CI, the mean change from baseline to Week 24 was divided by the standard deviation of the measure at baseline to calculate the effect size. This calculation provides a Cohen's *d* effect size value for changes observed after treatment. Wilcoxon sign rank analyses were performed comparing the mean improvement after treatment in each measure with zero to assess for statistical significance. A Bonferroni adjustment was made to account for the multiple statistical tests. As such, an alpha level of .0036 (.05 / 14) was used to assess statistical significance for the pre-treatment and the pre- to post-treatment results. Children who did not complete the post-treatment evaluation were excluded from these analyses.

To characterize the magnitude of the observed responses from pre- to post-treatment and their clinical significance, we used the Cohen's *d* effect sizes (Cohen, 1988; Verkleij et al., 2011) The following classifications were used to quantify the observed effect sizes: small effect $0.2 \le d < 0.5$, medium effect $0.5 \le d < 0.8$, and large effect $d \ge 0.8$.

For pre-treatment scales with a mean *d* score greater than one, a post hoc assessment of treatment effect was performed using only those children scoring 1.0 standard deviation above the mean. This allowed us to investigate changes in treatment in children who had the highest scores at baseline.

Downloaded from jad.sagepub.com at PENNSYLVANIA STATE UNIV on May 10, 2016

Table 3. Descriptive Statistics for *t* Scores and Effect Size (*d* Score) Based on the Mean and Standard Deviation From the Normal Sample for Each Subscale Scores of the Child Behavior Checklist at the Pre-Treatment Examination.

	t score			*d* score		
Scale	*M*	*SD*	% 1.5 *SD*	*M*	*SD*	*p* value[a]
Competence scales						
Social	46.14	10.0	15.9	−0.35	1.0	.034
Activities	46.29	10.0	15.6	−0.38	1.1	.066
School	45.04	8.6	13.3	−0.52	1.2	.007
Empirically based scales						
Anxious/depressed	53.91	5.6	11.1	−0.03	1.0	.24
Withdrawn/depressed	54.91	6.1	8.9	0.10	1.1	.78
Somatic complaints	61.02	7.8	31.1	1.36	1.7	<.001[b]
Social problems	54.07	5.4	4.4	−0.02	0.9	.51
Thought problems	53.22	4.7	4.4	−0.17	0.8	.036
Attention problems	55.58	7.1	11.1	0.21	1.1	.35
Rule breaking behavior	52.69	4.0	2.2	−0.26	0.7	.002[b]
Aggressive behavior	52.38	4.2	2.2	−0.37	0.8	.001[b]
Internalizing problems	54.44	10.0	20	0.48	1.2	.057
Externalizing problems	45.96	8.9	2.2	−0.36	0.8	<.001[b]

[a]Comparing mean with zero using a Wilcoxon sign rank test.
[b]Alpha level of .0036 (.05 / 14) based on Bonferroni adjustment.

Results

Pre-Treatment Data: Comparison With Normal Scores

From January 2009 to February 2010, 53 symptomatic children with CI enrolled in the study and completed baseline testing. The mean age (*SD*) of the children with CI at baseline was 11.5 (2.27); 57% were female, 49% were White, 43% were African American, and 30% reported Hispanic or Latino ethnicity. At baseline, the mean (*SD*) clinical findings were exodeviation of 2.1Δ (2.7) at distance and 10.0Δ (4.3) at near; NPC break of 13.7 cm (8.0); and PFV break at near of 10.7Δ (3.9); and a CISS score of 28.9 (9.0). The frequency of individual item endorsement on the CISS is listed in Table 2. A parent-reported diagnosis of ADHD was reported for 8 (15%) children but only 2 were currently being treated with a stimulant.

Prior to treatment, the mean (*SD*) *d* score for the Conners 3 ADHD Index was 1.27 (1.81) and was significantly different from the population norms ($p < .0001$). The *d* scores ranged from −0.66 to 6.21 with 16 scoring at 1.5 standard deviation or higher. To investigate the individual responses on the Conners 3 ADHD Index, we divided the index into inattentive items (six items) and hyperactive/impulsive items (four items) based on classification described in the manual (Conners, 2009). We assigned numerical values 0 (not true at all), 1 (just a little true), 2 (pretty much true), and 3 (very much true) to the response scale and compared the mean response with the inattentive and hyperactive/impulsive items for the Conners 3 ADHD Index. The item mean for the six inattention items was 1.17 ($SD = 0.77$), and the item mean for the hyperactive items was 0.74 ($SD = 0.66$). Compared with hyperactive items, inattention items were endorsed with significantly greater severity using a Wilcoxon sign rank test ($p < .0001$).

The mean (*SD*) effect sizes for the CBCL at baseline are shown in Table 3. Each score was compared with published normative values where 0 would indicate no difference from the normative population mean. For the competence scales (social, activities, and school), only the school competence scale approached significance and had a medium effect size. Children with symptomatic CI scored significantly higher on the somatic complaints scale with a large effect size ($d = 1.36$). The aggressive behavior scale and externalizing problems scale were significantly lower than mean values with small effect sizes ($d = −0.37$ and $d = −0.36$, respectively). The internalizing problems scale was elevated but did not reach statistical significance.

Pre- to Post-Changes With Treatment

Of the 53 symptomatic children with CI, 48 consented to OBVAT with 45 completing 16 weeks of OBVAT and 44 returning for the 24-week primary outcome examination (8 weeks after completing OBVAT). The mean age of those completing OBVAT was 11.4 years (range = 9-16 years) and 52% were female. Half of the participants reported their race as White/Caucasian with another 41% reporting African American. Twenty-seven percent of the children were of Hispanic or Latino ethnicity. Parents reported that 5

Downloaded from jad.sagepub.com at PENNSYLVANIA STATE UNIV on May 10, 2016

Table 4. The Pre- to Post-Treatment Values for the Clinical Signs and Symptoms of CI for Those Who Completed the Treatment and the 24-Week Outcome Visit.

	Eligibility		Week 24		Change		
Measure	*M*	*SD*	*M*	*SD*	*M*	*SD*	Range
CISS score	30.20	9.07	12.94	10.60	17.26	11.56	−11.5, 44.0
NPC break (cm.)	14.54	8.56	3.40	2.87	11.14	8.73	−6.3, 35.0
PFV break (Δ)	12.02	4.59	33.03	10.80	22.67	11.39	0.0, 44.0

Note. CI = convergence insufficiency; CISS = Convergence Insufficiency Symptom Survey; NPC = near point of convergence; PFV = positive fusional vergence.

Table 5. Descriptive Statistics for Effect Size of Pre- to Post-Treatment Changes (Week 24 Minus Baseline Divided by Standard Deviation at Baseline) in Each CBCL Subscale.

Scale	*M*	*SD*	*p* value[a]
Competence scales			
Social	0.10	0.7	.43
Activities	0.12	0.9	.29
School	0.35	0.8	.010
Empirically based scales			
Anxious/depressed	−0.36	0.9	<.001[b]
Withdrawn/depressed	−0.21	1.2	.36
Somatic complaints	−1.15	1.6	<.001[b]
Social problems	−0.12	0.8	.82
Thought problems	−0.33	0.9	.011
Attention problems	−0.23	1.0	.12
Rule breaking behavior	−0.027	0.6	.96
Aggressive behavior	0.021	0.6	.78
Internalizing problems	−0.67	1.2	<.001[b]
Externalizing problems	0.0056	0.6	.99

[a]Comparing mean to zero using a Wilcoxon sign rank test.
[b]Alpha level of .0036 (.05 / 14) based on Bonferroni adjustment.

(11%) of the children had been diagnosed with ADHD but only 1 was currently being treated with a stimulant.

Symptoms and clinical signs of CI improved significantly following treatment ($p < .0001$ for all measures; Table 4). A significant improvement after treatment was found for the Conners 3 ADHD Index with a medium effect size ($d = 0.58$) that was significantly different from 0 ($p < .0001$). The changes with treatment for the CBCL subscales are listed in Table 5. On the CBCL competency scales, school activities nominally improved but did not reach statistical significant after adjusting for multiple tests. Children improved significantly on the anxious/depressed, somatic complaints, and internalizing problems scales. For the anxious/depressed scale, the effect size for improvement was small ($d = 0.36$). A medium effect size was seen for the internalizing problems scale ($d = 0.67$), and a large effect size was seen for the somatic complaints scale ($d = 1.15$).

Additional analyses were performed investigating the effect of treatment of children who scored greater than 1 standard deviation above the mean at the pre-treatment examination. These analyses were limited to the Conners 3 ADHD Index and CBCL somatic complaints scale. Twenty-three children had a Conners 3 ADHD Index score greater than 1 standard deviation above the mean at pre-treatment, and this group experienced a large effect size after treatment ($d = 1.47$). For the CBCL somatic complaints scale, 25 children scored 1 standard deviation above the mean and also showed a large effect size following treatment ($d = 1.89$).

Discussion

To our knowledge, this is the first study that assessed a broad range of behavioral and emotional problems in children with symptomatic CI. Before treatment, these children manifest significantly more ADHD-like behaviors than the published norms, as measured by the Conners 3 ADHD Index. On the CBCL, children with symptomatic CI scored significantly higher on the somatic complaints scale. Following treatment for CI, the scores on the Conners 3 ADHD Index and the CBCL internalizing problem scales improved significantly, while the CBCL externalizing problems remained unchanged.

Strengths of the study included an assessment of emotional and behavioral problems in a well-defined sample of children with CI and investigation of the effects of treatment on the Conners 3 ADHD Index and CBCL. Limitations of the study include unmasked examinations, using only parental report for evaluating behaviors and emotional problems, and a lack of a sham treatment group to control for possible placebo effects derived from the treatment ritual (e.g., coming to a clinic for treatment and therapist–child interactions).

The higher frequency of ADHD-like behaviors on the Conners 3 ADHD Index found in children with symptomatic CI could be related to a sampling bias. That is, symptomatic children with CI and ADHD-like symptoms might be more likely to pursue eye care than symptomatic CI children without ADHD-like symptoms. In addition, we only

Downloaded from jad.sagepub.com at PENNSYLVANIA STATE UNIV on May 10, 2016

relied on parental report and did not get reports from the child's teacher who maybe a better judge of ADHD symptoms. We cannot rule out sampling bias at this time.

We found concurrent improvement in the clinical signs and symptoms associated with CI and the Conners 3 ADHD index scores following treatment. The changes in the Conners 3 ADHD index scores were the highest in children scoring at 1.0 standard deviation above the mean at baseline. This group showed an effect size of 1.47 following treatment. This pattern of results agrees with previous studies that indicated that symptoms and behaviors related to CI may be similar to some ADHD behaviors and improve with treatment (Barnhardt et al., 2012; Borsting et al., 2012; Borsting et al., 2005; CITT Study Group, 2008b; Rouse, Borsting, Mitchell, Kulp, et al., 2009). The effect size change observed in the children who scored high at baseline was significant and larger than typical placebo effects. However, without conducting a randomized masked trial using ADHD scales, we cannot conclude that treating symptomatic CI would result in a long-lasting reduction in ADHD behaviors.

On the CBCL at baseline, the largest difference from normative values was observed for the somatic category. This was largely affected by the questions about eye problems (67% responded somewhat true or very true) and headaches (59% responded somewhat true or very true). The response of eye problem would be expected from those with symptomatic CI's and headache is a common patient complaint in children with CI (Borsting, Rouse, Mitchell, et al., 2003). In fact, 57% of the CI children reported headaches sometimes, fairly often, or always when reading and doing close work on the CISS (Table 2). The somatic index on the CBCL also showed the largest effect size following treatment with children scoring high at baseline showing the largest improvements. This is consistent with the improvement in child-reported symptoms on the CISS (Table 4).

The combination of somatic symptoms, particularly headaches and eye problems, and parental concern about academic and inattention could indicate an increased risk of the child having a CI. Because CI is often missed on a school-based vision screening, a referral to an eye care professional may be indicated in such cases. Although we still need further studies to determine whether successful treatment of CI will result in concurrent improvement in attention, we do have sufficient evidence that successful treatment of CI does result in fewer somatic, perceptual, and performance symptoms as reported by the child. Two recent multicenter clinical trials comparing various treatments for school-aged children with CI demonstrated a significant reduction in symptoms related to near work and improvements in clinical signs following successful treatment of CI (CITT Study Group, 2008b; Scheiman, Mitchell, Cotter, Cooper, et al., 2005). From an eye care perspective, the reduction in vision-related symptoms and improvement in clinical signs of CI are the primary reasons for treatment. In addition, a recent study indicated that successful treatment of CI resulted in a lower frequency of adverse academic behaviors as reported by the parent. The results of this study indicate that further investigation of the possible effects of CI treatment on ADHD-like behaviors and other psychopathology is warranted. Our initial hypothesis is that the CI adversely affects attention and this may lead to problem behaviors noticed by parents.

In summary, parents of children with symptomatic CI report a higher frequency of ADHD-like behaviors as measured by the Conners 3 ADHD Index and more somatic problems. In an open trial, attention and internalizing problems improved following treatment with OBVAT. Further investigation into the impact of CI treatment on attention and internalizing problems is warranted.

Appendix

The CITT- RS Group includes the authors and the investigators listed below. Sites are listed in order of number of patients enrolled in the study (shown in parenthesis after site name and location). Personnel are listed as PI for principal investigator, E for examinor, SC for study coordinator, and VT for vision therapist

Study Center: Bascom Palmer Eye Institute (13)

Susanna Tamkins, OD (PI); Monica Dowling, PhD (VT); Courtney Ewert (SC); Mariana Nunez (SC); Eva Olivares (SC); Adam Perlman, OD (VT).

Study Center: NOVA Southeastern University (8)

Rachel Coulter, OD (PI); Deborah Amster, OD (E); Annette Bade, OD (SC); Mary Bartuccio, OD (VT); Gregory Fecho, OD (E): Nadine Girgis, OD (E); Janolyn Gregg, PhD (E); Beth Klein, (E); Jacqueline Rodena, OD (E).

Study Center—The Ohio State University College of Optometry (8)

Marjean Kulp, OD, MS (PI); Julie Peterson, OD, PhD, M.Ed (E); Kathleen Reuter, OD (VT); Nancy Stevens, MS, RD, LD (SC); Andrew Toole, OD, PhD (VT).

Study Center: Pennsylvania College of Optometry (7)

Michael Gallaway, OD (PI); Mark Boas, OD, MS (VT); Karen Pollack (SC); Ruth Shoge, OD (E).

Downloaded from jad.sagepub.com at PENNSYLVANIA STATE UNIV on May 10, 2016

Study Center: Southern California College of Optometry (7)

Susan Cotter, OD, MS (PI); Eric Borsting, OD, MS (E); Carmen Barnhardt, OD, MS (VT); Raymond Chu, OD, MS (VT); Susan Parker (SC)

Study Center: SUNY College of Optometry (6)

Jeffrey Cooper, MS, OD (PI); Audra Steiner, OD (E, Co-PI); Jennifer Han, OD (VT); Kelly Kao (VT); Debbie Luk, OD (VT); Grace Morano (VT).

Study Center: UAB School of Optometry (4)

Kristine Hopkins, OD (PI); Marcela Frazier, OD (E); Janene Sims, OD (E); Marsha Swanson, OD (E); Katherine Weise, OD (E); Michelle Anderson, OD (VT); Catherine Baldwin (SC)

Convergence Insufficiency Treatment Trial–Reading Study (CITT-RS) Study Chair

Mitchell Scheiman, OD (Study Chair); Susan Cotter, OD, MS (Vice Chair); Richard Hertle, MD (Vice Chair) Karen Pollack, (Study Coordinator).

CITT-RS Data Coordinating Center

Gladys Lynn Mitchell, MAS (PI); Austen Tanner (Student).

CITT-RS Executive Committee

Mitchell Scheiman, OD; Eric Borsting OD, MSEd; Christopher Chase, PhD; Susan Cotter OD, MS; Richard Hertle, MD; Marjean Kulp, OD, MS Lynn Mitchell, MAS.

Authors' Note

Portions of the study were presented as a poster at the Association of Research in Vision and Ophthalmology in April of 2011 and at the American Academy of Optometry in October of 2010 and 2011.

Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Dr. Arnold has received research funding and/or advisory board honoraria from Astra-Zeneca, Biomarin, CureMark, Lilly, Novartis, Noven, Roche, Seaside Therapeutics, and Shire, consulting honorarium from Tris Pharma, and travel support from Noven.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: The study was funded in part by a grant from the College of Optometrist in Vision Development and the Ohio State University College of Optometry Clinical Center.

References

Achenbach, T. M. (1991). *Manual for the CBCL/4-18 and profiles*. Burlington: Department of Psychiatry, University of Vermont.

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington, DC: Author.

Barnhardt, C., Cotter, S. A., Mitchell, G. L., Scheiman, M., & Kulp, M. T., & The Convergence Insufficiency Treatment Trial Study Group. (2012). Symptoms in children with convergence insufficiency: Before and after treatment. *Optometry and Vision Science*, *89*, 1512-1520.

Borsting, E., Mitchell, G. L., Kulp, M. T., Scheiman, M., Amster, D. M., Cotter, S., . . . Yamada, T. (2012). Improvement in academic behaviors after successful treatment of convergence insufficiency. *Optometry and Vision Science*, *89*, 12-18.

Borsting, E., Rouse, M. W., & Chu, R. (2005). Measuring ADHD behaviors in children with symptomatic accommodative dysfunction or convergence insufficiency: A preliminary study. *Optometry*, *76*, 588-592.

Borsting, E., Rouse, M. W., & Deland, P., & Convergence Insufficiency and Reading Study Group. (1999). Prospective comparison of convergence insufficiency and normal binocular children on the CIRS symptom survey. *Optometry and Vision Science*, *76*, 221-228.

Borsting, E., Rouse, M. W., Deland, P. N., Hovett, S., Kimura, D., Park, M., & Stephens, B. (2003). Association of symptoms and convergence and accommodative insufficiency in school-age children. *Optometry*, *74*, 25-34.

Borsting, E., Rouse, M. W., Mitchell, G., Schieman, M., Cotter, S., Cooper, J., . . . The Convergence Insufficiency Treatment Trial Group. (2003). Validity and reliability of the revised convergence insufficiency symptom survey in children ages 9-18 years. *Optometry and Vision Science*, *80*, 832-838.

Cohen, J. (1988). *Statistical power analyses for the behavioral sciences*. Hillsdale, NJ: Lawrence Erlbaum.

Conners, C. K. (1997). *Manual for Conners' Rating Scales*. Toronto, Ontario, Canada: Multi-Health Systems.

Conners, C. K. (2009). *Conners 3rd edition*. North Tonawanda, NY: Multi-Health Systems.

Convergence Insufficiency Treatment Trial Study Group. (2008a). The convergence insufficiency treatment trial: Design, methods, baseline data. *Ophthalmic Epidemiology*, *15*, 24-36.

Convergence Insufficiency Treatment Trial Study Group. (2008b). Randomized clinical trial of treatments for symptomatic convergence insufficiency in children. *Archives of Ophthalmology*, *126*, 1336-1349.

Granet, D. B., Gomi, C. F., Ventura, R., & Miller-Scholte, A. (2005). The relationship between convergence insufficiency and ADHD. *Strabismus*, *13*, 163-168.

Gronlund, M. A., Aring, E., Landgren, M., & Hellstrom, A. (2007). Visual function and ocular features in children and adolescents with attention deficit hyperactivity disorder, with and without treatment with stimulants. *Eye*, *21*, 494-502.

Kaufman, A., & Kaufman, N. (2004). *Manual Kaufman Brief Intelligence Test* (2nd ed.). Circle Pines, MN: AGS Publishing.

Letourneau, J., & Ducic, S. (1988). Prevalence of convergence insufficiency among elementary school children. *Canadian Journal of Optometry*, *50*, 194-197.

Downloaded from jad.sagepub.com at PENNSYLVANIA STATE UNIV on May 10, 2016

Letourneau, J., Lapierre, N., & Lamont, A. (1979). The relationship between convergence insufficiency and school achievement. *American Journal of Optometry and Physiological Optics*, *56*, 18-22.

Rouse, M., Borsting, E., Mitchell, G. L., Kulp, M. T., Scheiman, M., Amster, D., . . . The Convergence Insufficiency Treatment Trial Study Group. (2009). Academic behaviors in children with convergence insufficiency with and without parent-reported ADHD. *Optometry and Vision Science*, *86*, 1169-1177.

Rouse, M. W., Borsting, E., Hyman, L., Hussein, M., Cotter, S., Flynn, M., . . . De Land, P. N. (1999). Frequency of convergence insufficiency among fifth and sixth graders. *Optometry and Vision Science*, *76*, 643-649.

Rouse, M. W., Borsting, E., Mitchell, G. L., Cotter, S. A., Kulp, M., Scheiman, M., . . . The Convergence Insufficiency Treatment Trial Investigator Group. (2009). Validity of the convergence insufficiency symptom survey: A confirmatory study. *Optometry and Vision Science*, *86*, 357-363.

Scheiman, M., Cotter, S., Rouse, M., Mitchell, G., Kulp, M., Cooper, J., . . . The Convergence Insufficiency Treatment Trial Study Group. (2005). Randomized clinical trial of the effectiveness of base-in prism reading glasses versus placebo reading glasses for symptomatic convergence insufficiency in children. *British Journal of Ophthalmology*, *89*, 1318-1323.

Scheiman, M., Mitchell, G. L., Cotter, S., Kulp, M. T., Cooper, J., Rouse, M., . . . Wensveen, J. (2005). A randomized clinical trial of vision therapy/orthoptics versus pencil pushups for the treatment of convergence insufficiency in young adults. *Optometry and Vision Science*, *82*, 583-595.

Scheiman, M., Mitchell, L., Cotter, S., Cooper, J., Kulp, M., Rouse, M., & The Convergence Insufficiency Treatment Trial Study Group. (2005). A randomized clinical trial of treatments for convergence insufficiency in children. *Archives of Ophthalmology*, *123*, 14-24.

Scheiman, M., & Wick, B. (2002). *Clinical management of binocular vision*. Philadelphia, PA: Lippincott Williams & Wilkins.

Sheard, C. (1930). Zones of ocular comfort. *American Journal of Optometry and Archives of American Academy of Optometry*, *7*, 9-25.

Verkleij, M., van de Griendt, E. J., Kaptein, A. A., van Essen-Zandvliet, L., Duiverman, E., & Geenen, R. (2011). Behavioral problems in children and adolescents with difficult-to-treat asthma. *Journal of Asthma*, *48*, 18-24.

Author Biographies

Eric Borsting is a professor of optometry at the Southern California College of Optometry at Marshall B. Ketchum University. He has published several articles looking at the impact of convergence insufficiency on quality of life and academic behaviors.

G. Lynn Mitchell is an assistant professor in the College of Optometry at Ohio State University. She has served as the primary biostatistician and director of the Data Coordinating Center for several NEI- and industry-funded research studies.

L. Eugene Arnold is a board-certified child and adolescent psychiatrist, professor emeritus of psychiatry at Ohio State University, and author of more than 200 peer-reviewed articles on child mental health, many of them involving treatment of ADHD.

Mitchell Scheiman is a professor of optometry at the Pennsylvania College of Optometry at Salus University. He has been involved with multiple randomized clinical trials investigating the effectiveness of treatment of symptomatic convergence insufficiency.

Christopher Chase is a professor of optometry at Western University of Health Sciences, College of Optometry. He has conducted research on vision and reading for more than 25 years and studies the role of binocular function on academic performance.

Marjean Taylor Kulp is a professor of optometry and vision science at The Ohio State University College of Optometry.

Susan Cotter is a professor of optometry at the Southern California College of Optometry at Marshall B. Ketchum University who has been involved in numerous randomized clinical trials investigating convergence insufficiency, amblyopia, and other childhood disorders.

Downloaded from jad.sagepub.com at PENNSYLVANIA STATE UNIV on May 10, 2016