Improvement in Academic Behaviors Following Successful Treatment of Convergence Insufficiency

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Abstract

Purpose—To determine whether treatment of symptomatic convergence insufficiency (CI) has an effect on Academic Behavior Survey (ABS) scores.

Methods—The ABS is a 6-item survey developed by the Convergence Insufficiency Treatment Trial (CITT) Group that quantifies the frequency of adverse school behaviors and parental concern about school performance on an ordinal scale from 0 (never) to 4 (always) with total scores ranging from 0 to 24. The ABS was administered at baseline and after 12 weeks of treatment to the parents of 218 children ages 9-17 years with symptomatic CI, who were enrolled in the CITT and randomized into: 1) home-based pencil push-ups (HBPP); 2) home-based computer vergence/accommodative therapy and pencil push-ups (HBCVAT+); 3) office-based vergence/accommodative therapy with home reinforcement (OBVAT); and 4) office-based placebo therapy with home reinforcement (OBPT). Participants were classified as successful (n=42), improved (n=60), or non-responder (n=116) at the completion of 12 weeks of treatment using a composite measure of the symptom score, near point of convergence, and positive fusional vergence. Analysis of covariance methods were used to compare the mean change in ABS between response to treatment groups while controlling for the ABS score at baseline.

Results—The mean ABS score for the entire group at baseline was 12.85 (SD=6.3). The mean ABS score decreased (improved) in those categorized as successful, improved, and non-responder by 4.0, 2.9, and 1.3 points, respectively. The improvement in the ABS score was significantly related to treatment outcome (p<0.0001), with the ABS score being significantly lower (better) for children who were successful or improved after treatment as compared to children who were non-responders (p=0.002 and 0.043, respectively).

Conclusions—A successful or improved outcome after CI treatment was associated with a reduction in the frequency of adverse academic behaviors and parental concern associated with reading and school work as reported by parents.

Keywords

convergence insufficiency; exophoria; symptoms; vision therapy; orthoptics; reading; attention deficit hyperactivity disorder

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Convergence insufficiency (CI) is a common vision disorder that affects approximately 5% of school-aged children and is associated with symptoms such as visual fatigue, headaches, and double vision when reading and studying.[1-4] These types of symptoms, as measured by the Convergence Insufficiency Symptom Survey (CISS), are significantly more frequent in children with CI compared to children with normal binocular vision.[5, 6]

In addition to symptoms reported by children with CI on the CISS, their parents have reported a significantly greater level of adverse school behaviors on the Academic Behavior Survey (ABS) when compared to parents of children with normal binocular vision.[7] The parents of children with CI are more likely than parents of children with normal binocular vision, to report the presence of difficulty completing school work, avoiding reading and studying, and inattentiveness or distraction during reading. Additionally, parents of children with CI report that they worry more about their child's school performance as compared to parents of children with normal binocular vision.

Two recent multicenter clinical trials comparing various treatments for school-aged children with CI, demonstrated a clinically significant reduction in symptoms following successful treatment of CI.[8, 9] However, previous studies have not investigated whether or not the improvements in child reported symptoms are accompanied by a decrease in parental report of adverse school behaviors and parental worry. Parental report of adverse behaviors related to school work in children with symptomatic CI could have potential implications for the diagnosis of disorders that rely on parent observations of children's behaviors. For example, recent studies have suggested a possible relationship between CI and Attention Deficit Hyperactivity Disorder (ADHD).[7, 10-12] Borsting et al[12] noted that a number of symptoms frequently reported by children with CI (e.g., loss of concentration when reading or reading slowly) 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).[13, 14]

This study used the ABS to determine parents' perceptions of the frequency of adverse behaviors exhibited by their children when reading or performing school work and overall parental concern about the child's academic performance following the successful treatment of symptomatic CI in school-aged children.

METHODS

The study was supported through a cooperative agreement with the National Eye Institute of the National Institutes of Health and conducted by the Convergence Insufficiency Treatment Trial (CITT) Group at nine 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 the National Eye Institute. The CITT was registered at clinicaltrials.gov under identifier NCT00338611.

Children ages 9 to 17 years with symptomatic CI were recruited at participating CITT clinical centers. Major eligibility criteria for the trial included exodeviation at near at least 4Δ 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) [15] or minimum PFV of ≤15Δ base-out blur or break), and a CISS score of 16 or higher. A detailed description of eligibility criteria is provided elsewhere.[8, 16]

Eligible children were randomly assigned with equal probability to one of four treatment groups: 1) home-based pencil push-ups (HBPP): 2) home-based computer vergence/ accommodative therapy and pencil push-ups (HBCVAT+); 3) office-based vergence/ accommodative therapy with home reinforcement (OBVAT); and 4) office-based placebo therapy with home reinforcement (OBPT). Each child then completed 12 weeks of active therapy in his/her assigned treatment group. Outcome measures included the CISS score, near point of convergence (NPC) and positive fusional vergence (PFV) and were measured by an examiner who was masked to the child's treatment group. A subject's treatment outcome was classified as "successful", "improved" or "non-responder" based on the CISS score, NPC, and PFV measurements at the 12-week outcome examination. Successfully treated CI was defined as a score of less than 16 on the CISS, a normal NPC (i.e., less than 6 cm), and normal PFV (i.e., greater than 15Δ and passing Sheard's criterion). Improved CI was defined as a score of less than 16 *or* a 10 point or more decrease in the CISS score, *and* at least one of the following: normal NPC, an improvement in NPC of 4 cm or more, normal PFV or an increase in PFV of more than 10Δ. A subject was classified as a non-responder when the criteria for "successful" or "improved" were not met.

The ABS was developed by the CITT Study Group to query parents regarding behaviors that a parent could easily observe, such as avoiding near work and problems with completing schoolwork.[7] Previous research has shown that parent and child agreement is better for behaviors that are easily observable (such as walking up and down stairs), as opposed to reporting on somatic issues (such as amount of pain) which are more subjective.[17-19] A list of potential questions was field-tested by the CITT investigators and six questions were chosen for the final survey. Five questions relate to observable behaviors and one question addresses the parent's level of concern about school performance (Table 3). Each item is scored on an ordinal scale as follows; 0 (Never), 1 (infrequently), 2 (sometimes), 3 (fairly often), and 4 (Always), with total scores ranging from 0 to 24.[5, 20]

The following instructions are contained 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 completion of the survey.

Data Analysis

The ABS was designed as a secondary outcome measure in the CITT and as such the study was not powered to find differences in the mean ABS score between the four treatment modalities. In addition a score on the ABS was not an inclusion criteria for the study. Thus, we evaluated the relationship between change in ABS score (baseline score minus week 12 score) and response to treatment (i.e., successful, improved, or non-responder) rather than comparing treatment groups.

All descriptive statistics for the characteristics of the sample at baseline are reported as means and standard deviations. Estimates for mean change in ABS score (baseline score

minus week 12 score) are presented along with 95% confidence intervals. The confidence intervals allow the reader to assess the statistical significance of the change observed and to compare change between treatment response groups. That is, if a confidence interval contains zero then there is not a significant change in ABS score and if two confidence intervals overlap then there is likely not a significant difference between the two groups. A formal comparison of the mean change in ABS score for each treatment response groups (successful, improved or non-responder) was achieved using analysis of covariance methods (ANCOVA). The baseline ABS score was included as a covariate because of its high correlation with the observed change (R = 0.44, p < 0.0001) and the slight, non-significant (p = 0.50) differences at baseline between outcome response categories. The error rate for post-hoc pair-wise comparisons was controlled using the method of Tukey. Given the ordinal nature of the data, the Kruskal-Wallis test was used to compare the mean change in response for each item of the ABS between children classified as successful, improved or non-responder. Pearson correlation coefficients were used to assess the relationship between the change in ABS score and changes in signs (NPC and PFV) and symptoms (CISS) of CI. SAS version 9.2 (Cary, NC) was used for analysis.

RESULTS

Subjects

Between July 2005 and October 2006, 221 patients were enrolled in the study. Study retention was excellent with 218 completing the 12 weeks of treatment. The mean (SD) age of the patients was 11.8 (2.3) years; 59% were female, 55% were white, 30% were African American, and 34% reported Hispanic or Latino ethnicity. Descriptive statistics for selected findings at baseline are shown in Table 1. Other clinical characteristics have been previously reported.[8, 16] The mean ABS score at baseline was 12.8 (6.3). Of the 218 children who completed the study, 42 (19%) were classified as successful, 60 (28%) as improved, and 116 (53%) as non-responders to treatment. The mean ABS score at the outcome visit was 10.6 (6.0) which was significantly lower (better) than the score at baseline (p<0.0001).

Comparisons Based on Treatment Outcome

The distribution of ABS scores at baseline and week 12 for participants classified as successful, improved and non-responders are shown in Figure 1. Comparisons of changes in ABS scores between the three groups were performed after controlling for the ABS score at baseline. An interaction term between ABS at baseline and treatment response group was included in the initial model. As shown on Figure 2, the relationship between change in ABS (baseline score minus week 12 score) and treatment response was the same regardless of ABS score at baseline (p-value for interaction between group and ABS at baseline = 0.25). The mean ABS score decreased (improved) after 12 weeks of treatment in those categorized as successful, improved, and non-responder by 4.01, 2.94, and 1.27 points, respectively (p-values < 0.001, Table 2). Post hoc testing indicated that the ABS score was significantly lower (better) for subjects classified as either successful or improved compared to non-responders (p=0.002 and 0.043, respectively). There was no significant difference in improvement between subjects classified as successful or improved (p=0.44).

We can estimate whether the findings above are clinically meaningful by calculating the effect size (Cohen's D) of the change in score from baseline to week 12 for each treatment response group.[21] A four point change (as found in the successful treatment group) would translate into an effect size of 0.9. A 2.9 point change (as found in those who improved) translates into an effect size of 0.7.

To better understand the effect of treatment outcome on ABS score, comparisons of the change in response to each of the 6 questions of the ABS were made between the children classified as successful, improved, and non-responders (Table 3). For each question, the amount of change (improvement) was greatest in those who were successful, less in those improved and least in the non-responders. Given the non-significant difference in total score between the successful and improved groups, these two groups were combined for comparison with the non-responders. Significant differences in the change in response were observed for "Worry about school performance" (p=0.004) and "Fails to give attention to detail" (p=0.043). For both of these questions, the change in average item response for subjects who were successful or improved after treatment was more than double that observed in the non-responders. In fact, there was no appreciable change in the response to "Worry about school performance" among the parents of children who were non-responders to treatment.

Relationship with CI Signs and Symptoms

As shown in Figure 3, improvement in the ABS score was significantly correlated with reduction in symptom level as determined by the CISS (R=0.29, p<0.0001). A 15-point decrease on the CISS (as observed in the OBVAT group after treatment) was associated with a 2.1 point reduction in ABS score. The change in ABS score (baseline score minus week 12 score) was not, however, correlated with changes in NPC break (R=0.081, p=0.23), changes in PFV (R=0.002, p=0.97), or the ratio of change in PFV to change in near phoria (R=-0.004, p=0.96).

DISCUSSION

Improved and successful outcomes after treatment for symptomatic CI in school-age children were associated with an overall reduction in the frequency of adverse behaviors and parental concern associated with reading and school work as measured by the ABS. There was also a significant positive relationship between the reduction in ABS score and the CISS score.

Although the differences in overall ABS score between those who were successful or improved versus non-responders were statistically significant, the question arises as to the clinical significance of the reduction in the frequency of adverse behaviors. We estimated whether the finding is clinically meaningful by calculating the effect size (Cohen's d) of the change in score from baseline to week 12. According to Cohen, effect sizes greater than 0.50 are considered medium effects while values greater than 0.80 are considered large effects. Sloan et al[22] argues that an effect size of 0.5 is a conservative estimate of a clinically meaningful difference that is scientifically supportable. Our observed effect sizes in the successful and improved groups were 0.9 and 0.7. Thus, the improvement in behavior reported by the parents appears to be a clinically meaningful change.

Strengths of this study include an excellent follow-up rate (98.6%) and masked assessment at the 12 week outcome examination. In addition, the ABS has been shown to have excellent internal consistency with a Cronbach Alpha score of 0.92.[7] Limitations are that the ABS is a newly developed instrument and we have not yet assessed the between session reliability or validated the ABS with another survey instrument. Additionally, we were not able to identify whether parents pursued other educational treatments during the 12 week CI treatment intervention that may have impacted the ABS scores. However, we consider it unlikely that the successful and improved groups pursued other forms of care with greater frequency than the non-responder group during the relatively short (12 week) treatment time frame. Finally, due to the ABS being a secondary outcome measure and not powered to find differences between treatment groups we decided to look at the association between the

responses to treatment in CI with changes in ABS scores. With this analysis we cannot rule out a possible placebo effect resulting from the expectations occurring when the child entered a treatment study. The study did include a placebo treatment arm that controlled for therapist to patient interactions for office based treatment but the study did not include corresponding placebo treatment groups for the home-based treatment arms. Despite the above limitations, this study can yield an initial estimate of parental report of improvement in their child's adverse school related behaviors following treatment for CI.

Previous studies have indicated that parents of children with CI report more behaviors similar to those observed in ADHD than parents of children with normal binocular vision.[7, 23] In addition, Granet et al[10] found a higher prevalence of ADHD in children diagnosed with CI when conducting a retrospective review of charts. Similarly, Gronlund et al[11] (2007) found one sign of CI (i.e., abnormal NPC) in 24% of the ADHD group but only 6% of the reference group. The current study results combined with previous studies mentioned above suggest that impact of treatment on CI should be studied using outcome instruments that assess the behavioral or cognitive aspects of attention (e,g, Connors Ratings Scales or continuous performance tasks).[24, 25] To our knowledge this is the first study that has investigated the impact of treating symptomatic CI in children on parental report of behaviors associated with school work. In translating the results into clinical practice, clinicians can use this information to educate patients/parents about the potential effects of therapy for symptomatic CI in children. These data suggest that parents may report a reduction in the frequency of specific adverse school and may have less overall worry about academic performance after children with symptomatic CI show improvement or are successfully treated.

Acknowledgments

Appendix: 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: State University of New York College of Optometry (8 NBV, 28 CI)

Jeffrey Cooper, OD (PI); Audra Steiner, OD (E, Co-PI); Marta Brunelli (VT); Stacy Friedman, OD (VT); Steven Ritter, OD (E); Lily Zhu, OD (E); Lyndon Wong, OD (E); Ida Chung, OD (E); Kaity Colon (SC)

Study Center: Bascom Palmer Eye Institute (35 CI)

Susanna Tamkins, OD (PI); Hilda Capo, MD (E); Mark Dunbar, OD (E); Craig McKeown, MD (CO-PI); Arlanna Moshfeghi, MD (E); Kathryn Nelson, OD (E); Vicky Fischer, OD (VT); Adam Perlman, OD (VT); Ronda Singh, OD (VT); Eva Olivares (SC); Ana Rosa (SC); Nidia Rosado (SC); Elias Silverman (SC)

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

Rachel Coulter, OD (PI); Deborah Amster, OD (E); Gregory Fecho, OD (E); Tanya Mahaphon, OD (E); Jacqueline Rodena, OD (E); Mary Bartuccio, OD (VT); Yin Tea, OD (VT); Annette Bade, OD (SC)

Study Center: University of Alabama, Birmingham School of Optometry (7 NBV, 28 CI)

Kristine Hopkins, OD (PI); Marcela Frazier, OD (E); Janene Sims, OD (E); Marsha Swanson, OD (E); Katherine Weise, OD (E); Adrienne Broadfoot, MS, OTR/L (VT, SC); Michelle Anderson, OD (VT); Catherine Baldwin (SC)

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

Michael Gallaway, OD (PI); Brandy Scombordi, OD (E); Mark Boas, OD (VT); Tomohiko Yamada, OD (VT); Ryan Langan (SC), Ruth Shoge, OD (E); Lily Zhu, OD (E)

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

Marjean Kulp, OD, MS (PI); Michelle Buckland, OD, MS (E); Michael Earley, OD, PhD (E); Gina Gabriel, OD, MS (E); Aaron Zimmerman, OD, MS (E); Kathleen Reuter, OD (VT); Andrew Toole, OD, PhD (VT); Molly Biddle, MEd (SC); Nancy Stevens, MS, RD, LD (SC)

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

Susan Cotter, OD, MS (PI); Eric Borsting, OD, MS (E); Michael Rouse, OD, MSEd, (E); Carmen Barnhardt, OD, MS (VT); Raymond Chu, OD (VT); Susan Parker (SC); Rebecca Bridgeford (SC); Jamie Morris (SC); Javier Villalobos (SC)

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

David Granet, MD (PI); Lara Hustana, OD (E); Shira Robbins, MD (E); Erica Castro (VT); Cintia Gomi, MD (SC)

Study Center: Mayo Clinic (14 CI)

Brian G. Mohney, MD (PI); Jonathan Holmes, MD (E); Melissa Rice, OD (VT); Virginia Karlsson, BS, CO (VT); Becky Nielsen (SC); Jan Sease, COMT/BS (SC); Tracee Shevlin (SC)

CITT Study Chair

Mitchell Scheiman, OD (Study Chair); Karen Pollack (Study Coordinator); Susan Cotter, OD, MS (Vice Chair); Richard Hertle, MD (Vice Chair); Michael Rouse, OD, MSEd (Consultant)

CITT Data Coordinating Center

Gladys Lynn Mitchell, MAS, (PI); Tracy Kitts, (Project Coordinator); Melanie Bacher (Programmer); Linda Barrett (Data Entry); Loraine Sinnott, PhD (Biostatistician); Kelly Watson (Student worker); Pam Wessel (Office Associate)

National Eye Institute, Bethesda, MD

Maryann Redford, DDS, MPH

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Data and Safety Monitoring Committee

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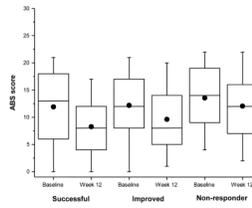
Figure 1.
Box plots for the Academic Behavior Survey at Baseline and the 12 week outcome visit, by treatment outcome. The outer limits of each box represent the 25th and 75th percentiles of the distribution. The median is shown as the line within each box while the mean is represented by the dot within each box.
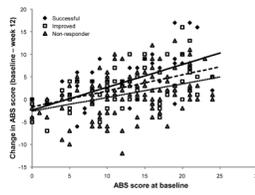
Figure 2.
Scatter plot of change in ABS (baseline score minus week 12 score) and ABS at baseline by treatment response.
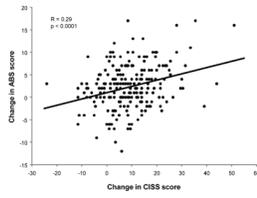
Figure 3.
Scatter plot of changes in ABS (baseline score minus week 12 score) and CISS from
baseline.

Table 1

Descriptive statistics for clinical findings at baseline.

Characteristic	Mean	Std	Range
Distance phoria (Δ)	1.9 exo	2.8	15 exo, 4 eso
Near phoria (Δ)	9.3 exo	4.4	2 exo, 25 exo
NPC break (cm)	14.3	7.6	6.0, 49.3
NPC recovery (cm)	17.9	8.2	7.5, 52.0
PFV break (Δ)	12.7	4.7	2.3, 31.7
PFV recovery (Δ)	8.8	4.5	0.0, 24.0
CISS	29.9	8.9	16, 58

Table 2

Mean Academic Behavior Survey scores at baseline and the 12-week outcome based on treatment outcome in the Convergence Insufficiency Treatment Trial. The table also presents the 95% confidence interval (CI) for the changes observed for each group.

	Baseline		Week 12		Improvement	
	Mean	95% CI	Mean[a]	95% CI	Mean[a]	95% CI
Successful	11.90	9.8 – 14.0	8.90	7.6 – 10.2	4.01	2.7 – 5.3
Improved	12.18	10.5 – 13.8	9.96	8.8 – 11.1	2.94	1.8 – 4.1
Non-responder	13.54	12.5 – 14.6	11.64	10.8 – 12.4	1.27	0.5 – 2.1
	ANOVA p = 0.22		ANCOVA p = 0.001		ANCOVA p = 0.001	

[a] Mean adjusted for ABS score at baseline

CI = confidence interval

Table 3

Mean improvement in score for each item of the Academic Behavior Survey by treatment outcome at 12 weeks. The table also presents the 95% confidence interval for the changes observed for each group.

Item	Successful	Improved	Non-responder	p-value
How often does your child have difficulty completing assignments at school?	0.55 (0.2, 0.9)	0.47 (0.2, 0.7)	0.28 (0.1, 0.5)	0.32
How often does your child have difficulty completing homework?	0.50 (0.2, 0.9)	0.24 (−0.03, 0.5)	0.21 (0.01, 0.4)	0.43
How often does your child avoid or say he/she does not want to do tasks that require reading or close work?	0.67 (0.3, 1.1)	0.66 (0.3, 1.0)	0.48 (0.3, 0.7)	0.36
How often does your child fail to give attention to details or make careless mistakes in schoolwork or homework?	0.74 (0.4, 1.1)	0.42 (0.2, 0.7)	0.20 (0.0, 0.4)	0.043
How often does your child appear inattentive or easily distracted during reading or close work?	0.62 (0.3, 1.0)	0.53 (0.2, 0.8)	0.35 (0.1, 0.6)	0.16
How often do you worry about your child's school performance?	0.57 (0.1, 1.1)	0.42 (0.1, 0.8)	0.02 (−0.2, 0.3)	0.004

The p-values reported in the table represent comparisons of the successful+ improved group to the non-responder group.