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ORIGINAL ARTICLE

Relationship Between Clinical Signs and Symptoms of Convergence Insufficiency

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ABSTRACT

Purpose. The percentage of children who are symptomatic has been shown to increase with the number of signs of convergence insufficiency (CI). Our goal was to investigate whether there is a relationship between the severity of the clinical signs of CI and symptom level reported in children with a three-sign symptomatic CI.

Methods. The Convergence Insufficiency Treatment Trial enrolled 221 children with symptomatic CI from ages 9 to 17 years. Inclusion criteria included the following three signs of CI: (1) exophoria at near at least 4Δ greater than at distance, (2) insufficient positive fusional vergence (PFV) at near, and (3) a receded near point of convergence (NPC) of 6 cm break or greater. The relationships between the severity of each sign of CI (mild, moderate, and severe) and the level of symptoms as measured by the Convergence Insufficiency Symptom Survey (CISS) at baseline were evaluated.

Results. Mean CISS scores were not significantly different between mild, moderate, and severe exophoria ($p = 0.60$), PFV blur ($p = 0.99$), Sheard's criterion ($p = 0.89$), or NPC break ($p = 0.84$). There was also no difference between the frequency of subjects scoring at mild, moderate, or severe levels on the CISS and the severity of each sign of CI. Correlations between individual clinical signs and the CISS score were very low and not statistically significant.

Conclusions. Among symptomatic children with a CISS score of 16 or higher and three clinical signs of CI, there is no further association between the severity of the clinical signs and their level of symptoms.

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Key Words: convergence insufficiency, vision therapy, orthoptics, vergence/accommodative therapy, home-based computer therapy, exophoria, convergence insufficiency symptom survey, Sheard's criterion

Convergence insufficiency (CI) is a common binocular vision disorder in children and is associated with symptoms such as eye fatigue, headaches, and double vision during reading and close work.[1–6] Convergence insufficiency is typically characterized as a syndrome of clinical signs most often defined by exophoria at near, a receded near point of convergence (NPC), and reduced positive fusional vergence (PFV) at near.[3,4] The Convergence Insufficiency Symptom Survey (CISS), a validated CI-specific symptom assessment instrument, has shown that individuals with CI are much more likely to be symptomatic than those with normal binocular vision.[6,7] Cohen et al.[8] found modest correlations between symptoms and clinical signs of CI (NPC and PFV), but they did not classify the severity of the CI. Rouse et al.[4] have reported that children having all three clinical signs of CI (exophoria at near, receded NPC, and reduced PFV) are more symptomatic than children who exhibit only one or two of the clinical signs. Despite the common clinical impression that symptoms are worse in more severe cases of CI, the relationship between the severity of the clinical signs of CI and level of presenting symptoms in children is unknown.

We recently completed the Convergence Insufficiency Treatment Trial (CITT), a randomized multicenter clinical trial that evaluated different modes of treatment for symptomatic CI in childhood.[9] Symptoms were quantified in a standardized manner at baseline using the CISS. These data provide an opportunity to gain a better understanding of the relationship between the severity of these three clinical measures and the level of symptoms in children with the three-sign, symptomatic CI. The aim of this study was to investigate the relationship between the severity of clinical signs of CI and the symptom level in children with all three signs and symptomatic CI.

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METHODS

The study was supported through a cooperative agreement with the National Eye Institute of the National Institutes of Health and was conducted by the CITT Group at nine clinic sites. The protocol and Health Insurance Portability and Accountability Act–compliant informed consent forms were approved by the respective institutional review boards. A parent or guardian of each study subject gave written informed consent, and each subject gave assent as required. An independent Data Safety Monitoring Committee provided study oversight. The study is registered at www.clinicaltrials.gov, Identifier No. NCT00338611. The complete manual of procedures is available on the CITT Web site at http://optometry.osu.edu/research/CITT/8581.cfm (accessed March 9, 2012).

Subject Selection

Major eligibility criteria for the CITT included children aged 9 to 17 years with symptomatic CI defined as (1) an exodeviation at near at least 4Δ greater than at far, (2) insufficient PFV at near (PFV ≤15Δ base-out blur or break or failing Sheard's criterion [PFV less than twice the near phoria][10]), (3) a receded NPC break (≥6 cm), and (4) a symptom score of 16 or higher on the CISS (described below).[9] In addition, children were required to have best-corrected visual acuity at distance and near of 20/25 or better, no constant strabismus, vertical phoria ≤1Δ, and monocular accommodative amplitude ≥5D. Children with myopia ≥6.00D sphere, hyperopia ≥5.00D sphere, astigmatism ≥4.00D, and ≥2.00D of spherical equivalent (SE) anisometropia were excluded. For lesser amounts of refractive error, a refractive correction was required to be worn for a least 2 weeks before enrollment when the magnitude of uncorrected refractive error or change in refractive error (as determined by cycloplegic refraction) was equal to or exceeded −0.50D of SE myopia, +1.50D of SE hyperopia, 0.75D of astigmatism, or 1.50D of anisometropia in any meridian. Asymmetric reduction of hyperopia by up to 1.25D was allowed, and full correction of myopia was required. A complete listing of eligibility and exclusion criteria has been published previously.[11]

Examination Procedures

Symptom level was measured using the CISS (Fig. 1), a valid and reliable self-report symptom inventory. The CISS uses a Likert-type scale with responses from 15 items summed to obtain an overall CISS score, with symptom severity ranging from 0 (asymptomatic) to 60 (most symptomatic).[6,7] The CISS was administered to each child at baseline, first before, and then after clinical testing. To administer the CISS, the examiner read aloud each of the 15 questions while the child viewed a card listing the five possible responses (never, infrequently, sometimes, fairly often, or always). The child responded how often each symptom occurred. Each response option had a corresponding score that ranged from 0 points (never) to 4 points (always); the points from the 15 questions were added to obtain a CISS total score. A score of 16 or higher was considered symptomatic.[6,7] The mean CISS score from the two CISS administrations at baseline was used for all data analysis. This is analogous to our protocol of using the average of three measurements of NPC and PFV in all data analyses. Previous analyses from our pilot data indicate that using two measurements of CISS ensures a within-person intraclass correlation of at least 0.80. In this study, the mean difference between the two administrations at baseline was −0.39 (p value comparing difference to zero = 0.17) with 95% limits of agreement of ±8 points.[12]

Other baseline testing included best-corrected visual acuity at distance and near; cover testing at distance and near; NPC, PFV, and negative fusional vergence at near (fusional convergence and divergence amplitudes with a prism bar); near stereoacuity; monocular accommodative amplitude (push-up method); monocular accommodative facility (the ability to quickly achieve clear vision while alternately viewing 20/30 print through +2D and −2D lenses); cycloplegic refraction; and an ocular health evaluation. An accommodative target (20/30 letter[s]) was used for cover testing, NPC, fusional vergence testing, and assessment of accommodative amplitude. CITT-trained and certified optometrists or ophthalmologists performed all testing using a previously described standardized protocol,[11] which is available in its entirety at http://optometry.osu.edu/research/CITT/8581.cfm (accessed March 7, 2012).

Classification of Severity of Clinical Signs

Each sign of CI was classified as mild, moderate or severe based on means and standard deviations (SD) from previously published normative studies. For near exophoria, cut points were as follows: mild ≤8 exo (≤1SD), moderate >8 to <13 exo (>1SD to <2SD), and severe ≥13 exo (≥2SD).[13] For PFV, cut points for were as follows: mild ≥15Δ (≤1SD), moderate >7Δ to <15Δ (>1SD to <2SD), and severe ≤7Δ (≥2SD).[14] For NPC, the cut points were as follows: mild 6 to <9 cm (≥1SD to <2SD), moderate 9 to <12 cm (≥2SD to <3SD), and severe ≥12 cm (≥3SD).[15] For Sheard's criterion, normative data to establish cut points are not available. Therefore, we divided the range of findings into three levels. A mild deficit was considered to be PFV ≥ 1.5 × near phoria, a severe deficit was PFV < near phoria, and a moderate deficit was values in between these ranges.

Classification of Symptom Level

Data from two previous studies of children with three clinical signs of CI (n = 158) were used to define the severity of symptom level.[16,17] All of these children were symptomatic with a CISS score of 16 or higher. In these studies, CISS scores ranged from 16 (least symptomatic) to 60 (most symptomatic). Tertiles of the CISS distribution were used because the CISS data are not normally distributed. The cut points for the level of symptoms were as follows: mild (≤33rd percentile or a CISS score ≤24), moderate (>33rd percentile to <67th percentile or CISS scores ranging from 24.5 to 34), and severe (≥67th percentile or a CISS score >34).

Data Analysis

The relationship between the severity level (mild, moderate, or severe) for each clinical sign and symptom level as indicated by the CISS score was examined using analysis of variance models. Mantel-Haenszel χ^2 tests were used to examine the relationship

Clinician instructions: Read the following subject instructions and then each item exactly as written. If subject responds with "yes" - please qualify with frequency choices. **Do not give examples.**
Subject instructions: Please answer the following questions about how your eyes feel when reading or doing close work. First think about whether or not you have the symptom. If you do, please tell me whether the problem occurs: Infrequently (not very often), Sometimes, Fairly Often, or Always.

		Never	Infrequently	Sometimes	Fairly often	Always
1.	Do your eyes feel tired when reading or doing close work?					
2.	Do your eyes feel uncomfortable when reading or doing close work?					
3.	Do you have headaches when reading or doing close work?					
4.	Do you feel sleepy when reading or doing close work?					
5.	Do you lose concentration when reading or doing close work?					
6.	Do you have trouble remembering what you have read?					
7.	Do you have double vision when reading or doing close work?					
8.	Do you see the words move, jump, swim or appear to float on the page when reading or doing close work?					
9.	Do you feel like you read slowly?					
10.	Do your eyes ever hurt when reading or doing close work?					
11.	Do your eyes ever feel sore when reading or doing close work?					
12.	Do you feel a "pulling" feeling around your eyes when reading or doing close work?					
13.	Do you notice the words blurring or coming in and out of focus when reading or doing close work?					
14.	Do you lose your place while reading or doing close work?					
15.	Do you have to re-read the same line of words when reading?					
To obtain score, total the number of "X"s in each column						
Multiply by the column value		x0	x1	x2	x3	x4
Sum 5 values						

SCORE: _____

FIGURE 1.
Convergence Insufficiency Symptom Survey.

between severity of clinical signs and symptom level based on tertiles of the CISS distribution. Lastly, Pearson correlation coefficients were used to assess the association between the individual clinical signs of CI (near exophoria, NPC break, PFV blur, and Sheard's criterion) and the CISS score. Several additional variables that are often associated with CI (e.g., magnitude of difference between the distance and near phorias, NPC recovery, PFV break, and PFV recovery) were also compared to CISS scores. All data analyses were performed using SAS (version 9.1, SAS Institute, Cary, NC).

RESULTS

Demographic and clinical characteristics of the 221 subjects enrolled into the CITT have been published previously.[9,11] In brief, the mean age was 11.8 years and 59% were female. Race was as follows: 55% White, 30% African American, and 15% other; 34% reported Hispanic ethnicity.

The mean (SD) CISS scores for mild, moderate, and severe levels of exophoria, PFV blur, Sheard's criterion, and NPC break are shown in Table 1. The difference in mean CISS scores between the mild, moderate, and severe categorizations for these four clinical signs are not significantly different (all p values $\geq$0.60). There are 39 subjects in the "mild" category who would pass Sheard's criteria. Exclusion of these subjects, however, does little to the reported mean symptom score, changing it from 30.10 to 30.74 (SD = 8.7, p value comparing Sheard's criterion level = 0.75). Table 2 reports the number of subjects in each tertile of CISS score by severity level of the signs of CI. Mantel-Haenszel χ^2 analysis showed no significant association between symptom level as measured by the CISS and severity of exophoria (p = 0.96),

TABLE 1.
CISS score by severity of different clinical measures of CI

Severity	Definition	n (%)	Mean score	SD
Near phoria, Δ				
Mild ≤1SD	≤8 exophoria	120 (54)	30.40	9.0
Moderate >1SD to <2 SD	>8 to <13 exophoria	60 (27)	28.36	8.7
Severe ≥ 2SD	≥13 exophoria	41 (18)	30.40	9.1
Positive fusional vergence (PFV) blur, Δ				
Mild ≤1SD	≥15Δ	27 (12)	30.00	8.9
Moderate >1SD to <2SD	>7Δ to <15Δ	156 (71)	29.81	9.0
Severe ≥2SD	≤7Δ	38 (17)	29.91	9.2
Sheard's criterion				
Mild	PFV blur ≥ 1.5× near phoria	81 (37)	30.10	9.0
Moderate	PFV blur ≥ near phoria but <1.5× near phoria	75 (34)	29.45	8.8
Severe	PFV blur < near phoria	65 (29)	30.00	9.3
Near point of convergence break, cm				
Mild ≥1SD to <2SD	6 to <9 cm	61 (28)	29.70	9.2
Moderate ≥2SD to <3SD	9 to <12 cm	53 (24)	29.32	8.2
Severe ≥3SD	≥12 cm	107 (48)	30.20	9.3

PFV blur (p = 0.77), Sheard's criterion (p = 0.92), or NPC break (p = 0.95). As shown in Table 3, there were no significant correlations between symptom level as measured by the CISS and any of the clinical findings (all r values ≤ 0.094; all p values ≥ 0.17). This is confirmed by scatter plots of CISS score versus exophoria (Fig. 2), versus PFV (Fig. 3), and versus NPC (Fig. 4).

DISCUSSION

In this study, we investigated the relationship between the severity of clinical signs and the level of symptoms among children with symptomatic three-sign CI. In other words, do children with more severe three-sign CI report more symptoms than children with less severe three-sign CI? We found that mean CISS scores were not significantly different between those with mild, moderate, or severe clinical signs (exophoria, PFV, Sheard phoria/vergence relationship, or NPC). Similarly, the percentage of subjects with higher levels of symptoms did not increase as the signs became more severe. Finally, correlations between individual clinical signs and the CISS score were low and not statistically significant. Therefore, the results of this study showed no significant

TABLE 2.
Number (%) of subjects in each category of CI Symptom Survey score, by severity of different clinical measures of CI

		CISS score		
Severity	Definition	≤24 Mild	24.5 to 34 Moderate	>34 Severe
Near phoria, Δ				
Mild ≤1SD	≤8 exophoria	36 (30.0)	47 (39.2)	37 (30.8)
Moderate >1SD to <2SD	>8 to <13 exophoria	25 (41.7)	21 (35.0)	14 (23.3)
Severe ≥ 2SD	≥13 exophoria	13 (31.7)	12 (29.3)	16 (39.0)
Positive fusional vergence (PFV) blur, Δ				
Mild ≤1SD	≥15Δ	8 (29.6)	10 (37.0)	9 (33.3)
Moderate >1SD to <2SD	>7Δ to <15Δ	55 (35.3)	53 (34.0)	48 (30.8)
Severe ≥2SD	≤7Δ	11 (29.0)	17 (44.7)	10 (26.3)
Sheard's criterion				
Mild	PFV blur ≥ 1.5× near phoria	25 (30.9)	32 (39.5)	24 (29.6)
Moderate	PFV blur ≥ near phoria but < 1.5× near phoria	26 (34.7)	27 (36.0)	22 (29.3)
Severe	PFV blur < near phoria	23 (35.4)	21 (32.3)	21 (32.3)
Near point of convergence break, cm				
Mild ≥1SD to <2SD	6 to <9 cm	19 (31.1)	23 (37.7)	19 (31.1)
Moderate ≥2SD to <3SD	9 to <12 cm	19 (35.9)	20 (37.7)	14 (26.4)
Severe ≥3SD	≥12 cm	36 (33.6)	37 (34.6)	34 (31.8)

TABLE 3.

Pearson correlation coefficients and p values describing the relationship between clinical measures of CI and the CISS symptom score

Clinical measure	Pearson correlation	p*
Exophoria at near, Δ	0.054	0.42
Positive fusional vergence – blur, Δ	−0.018	0.79
Positive fusional vergence – break, Δ	−0.025	0.71
Positive fusional vergence – recovery, Δ	−0.072	0.28
PFV – blur relative to exophoria at near	−0.00032	0.99
Near point of convergence – break, cm	0.068	0.32
Near point of convergence – recovery, cm	0.094	0.17
Difference between distance and near phoria	0.027	0.70

*Comparing correlation to zero.

association between symptom level and the severity of individual clinical measures of CI in children with symptomatic CI.

Previous research has shown an association between symptoms and signs when subjects with and without binocular vision problems are included.[5–8] Furthermore, Rouse et al.[4] showed that a higher percentage of children with three-sign CI were symptomatic compared to those with fewer signs of CI. Therefore, the lack of an association between the severity of signs and the level of symptoms found in this study may be attributable to the fact that all children had symptomatic three-sign CI. Once children reach a certain threshold level (i.e., three signs of CI), there is no further association between the severity of signs and the frequency of symptoms. The CITT group has reported that children more frequently report performance-related symptoms (i.e., loss of place with reading, reading slowly, loss of concentration) compared to eye-related symptoms (i.e., eyes hurt, blurred vision, headaches, diplopia).[18] Also, a high percentage of children with symptomatic three-sign CI shows that these performance-related symptoms occur fairly often or always. Thus, the lack of any further association between the severity of clinical signs and the level of symptoms may indicate a plateau in symptoms as measured by the CISS. Another possible explanation is that, as exophoria increases and/or as convergence ability worsens, some subjects may either develop suppression or avoid near activities to reduce or eliminate symptoms. We did not evaluate suppression, however.

Lastly, the lack of an association between the severity of signs and the level of symptoms found in this study may be explained by the nature of the data. The CITT did not measure clinical signs or administer the CISS after prolonged near work. It is plausible that signs and symptoms associated with CI may change if testing was performed after the visual system was stressed. Further studies are necessary to determine the effect of visual fatigue on the relationship between the signs and the symptoms of CI.

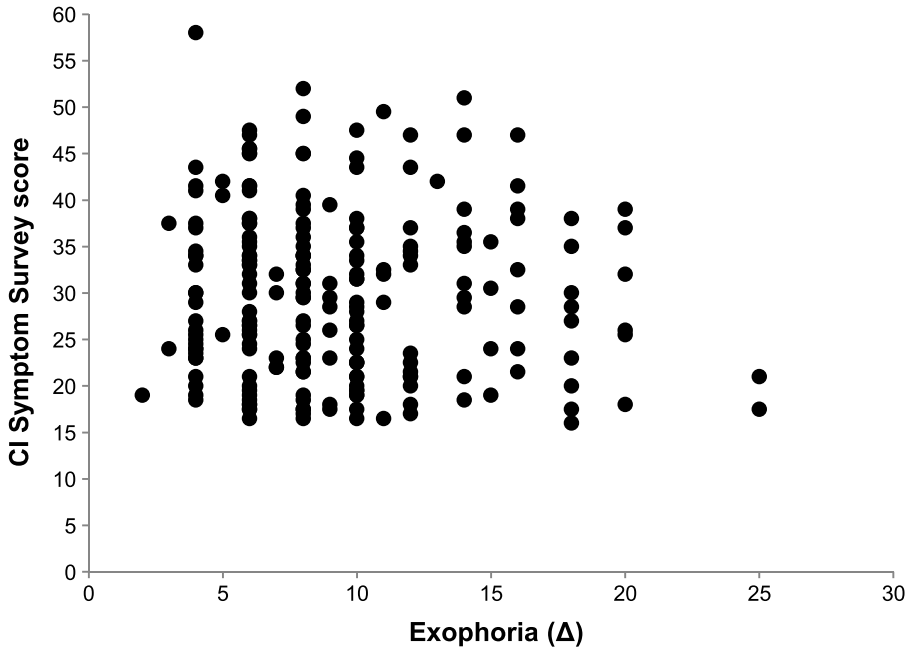

FIGURE 2.

Scatter plot of Convergence Insufficiency Symptom Survey score and near phoria.

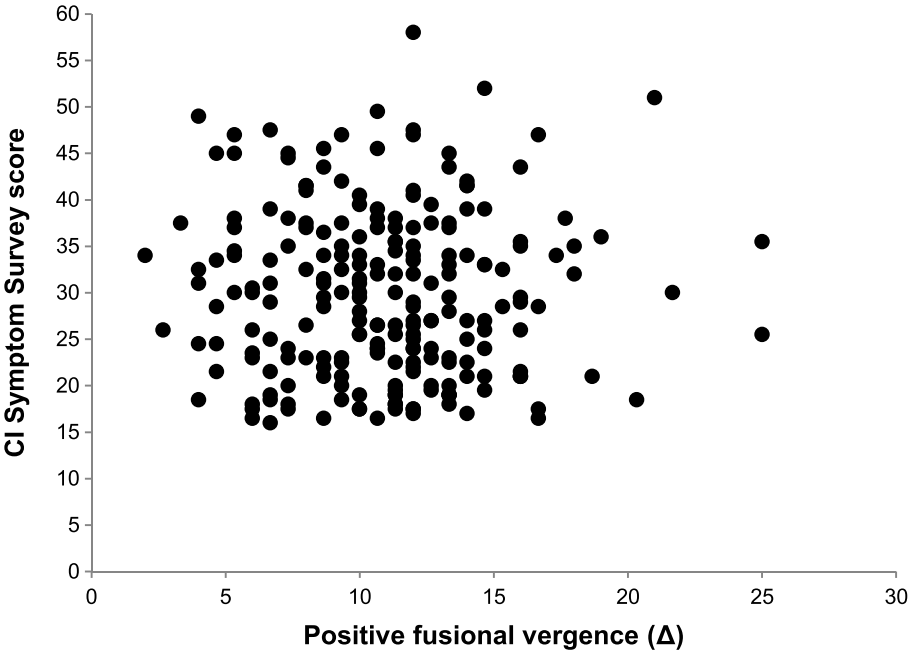

FIGURE 3.
Scatter plot of Convergence Insufficiency Symptom Survey score and positive fusional vergence blur.

The goal of this study was to determine whether worsening signs of CI were related to increases in symptoms. While other researchers have noted a positive correlation between symptom level and number of signs of CI, there have been no publications examining the association of signs and symptoms among children with three-sign CI. A significant relationship of symptoms with one or more of the signs of CI might suggest more targeted treatment. For example, if more receded near points of convergence were related to higher symptom levels, then one could argue that even small improvements in near point would result in reductions in symptoms. We found no such significant correlations although we know from previous publications[9,16] that treatments for CI (which coincidently improve NPC and PFV) have resulted in large reductions in the CISS score. Our conclusion, therefore, is that although there is a positive relationship between symptom level and the number of signs of CI (0, 1, 2, or 3), once the three-sign threshold has been reached, the wide range of symptom level is not related to severity of any one sign of CI.

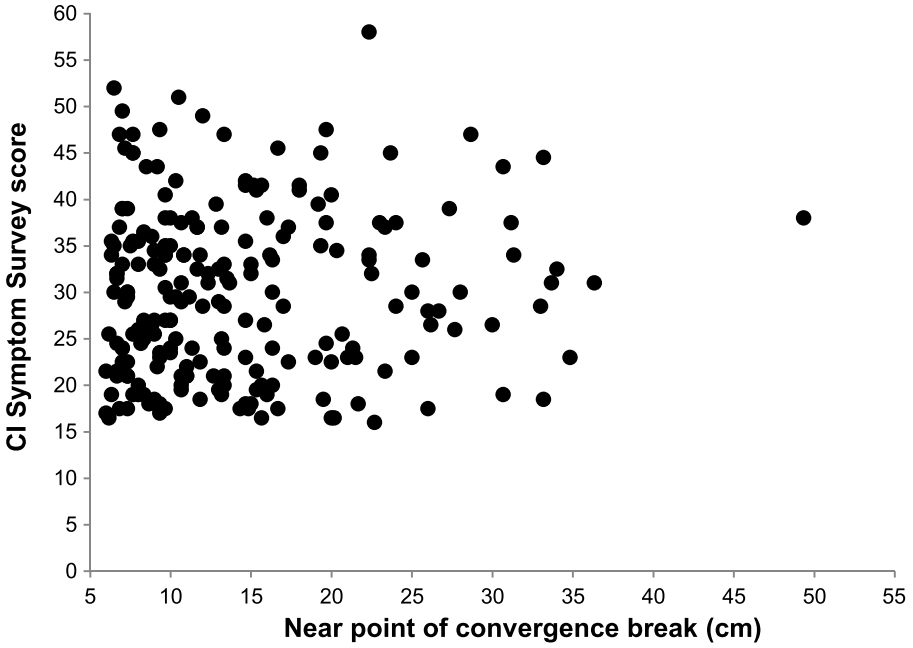

FIGURE 4.
Scatter plot of Convergence Insufficiency Symptom Survey score and near point of convergence break.

CONCLUSIONS

Among symptomatic children with a CISS score of 16 or higher and three clinical signs of CI, increased severity of the clinical signs is not associated with a further increase in level of symptoms.

ACKNOWLEDGMENTS

The Convergence Insufficiency Treatment Trial Investigator Group Clinical Sites

Sites are listed in order of the number of subjects enrolled in the study with the number of subjects enrolled is 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.

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Study Center: SUNY College of Optometry (28): Jeffrey Cooper, MS, 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).

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Study Center: University of CA San Diego: Ratner Children's Eye Center (17): David Granet, MD (PI); Lara Hustana, OD (E); Shira Robbins, MD (E); Erica Castro (VT); Cintia Gomi, MD (SC).

Study Center: Mayo Clinic (14): 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).

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REFERENCES

1. Letourneau JE, Lapierre N, Lamont A. The relationship between convergence insufficiency and school achievement. Am J Optom Physiol Opt 1979;56:18–22.
2. Letourneau J, Ducic S. Prevalence of convergence insufficiency among elementary school children. Can J Optom 1988;50:194–7.
3. Rouse MW, Borsting E, Hyman L, Hussein M, Cotter SA, Flynn M, Scheiman M, Gallaway M, De Land PN. Frequency of convergence insufficiency among fifth and sixth graders. The Convergence Insufficiency and Reading Study (CIRS) group. Optom Vis Sci 1999;76:643–9.
4. Rouse MW, Hyman L, Hussein M, Solan H. Frequency of convergence insufficiency in optometry clinic settings. Convergence Insufficiency and Reading Study (CIRS) Group. Optom Vis Sci 1998;75:88–96.
5. Borsting E, Rouse MW, Deland PN, Hovett S, Kimura D, Park M, Stephens B. Association of symptoms and convergence and accommodative insufficiency in school-age children. Optometry 2003;74:25–34.
6. Borsting EJ, Rouse MW, Mitchell GL, Scheiman M, Cotter SA, Cooper J, Kulp MT, London R. Validity and reliability of the Revised Convergence Insufficiency Symptom Survey in children aged 9 to 18 years. The Convergence Insufficiency Treatment Trial (CITTS) Study Group. Optom Vis Sci 2003;80:832–8.
7. Rouse M, Borsting E, Mitchell GL, Cotter SA, Kulp M, Scheiman M, Barnhardt C, Bade A, Yamada T. Validity of the convergence insufficiency symptom survey: a confirmatory study. The Convergence Insufficiency Treatment Trial (CITTS) Study Group. Optom Vis Sci 2009;86:357–63.
8. Cohen Y, Segal O, Barkana Y, Lederman R, Zadok D, Pras E, Morad Y. Correlation between asthenopic symptoms and different measurements of convergence and reading comprehension and saccadic fixation eye movements. Optometry 2010;81:28–34.
9. The Convergence Insufficiency Treatment Trial (CITTS) Study Group. Randomized clinical trial of treatments for symptomatic convergence insufficiency in children. Arch Ophthalmol 2008;126:1336–49.
10. Sheard C. Zones of ocular discomfort. Am J Optom 1930;7:9–25.
11. The Convergence Insufficiency Treatment Trial (CITTS) Study Group. The convergence insufficiency treatment trial: design, methods, and baseline data. Ophthalmic Epidemiol 2008;15:24–36.
12. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet 1986;1:307–10.
13. Morgan MW. The clinical aspects of accommodation and convergence. Am J Optom Arch Am Acad Optom 1944;21:301–13.
14. Scheiman M, Herzberg H, Frantz K, Margolies M. A normative study of step vergence in elementary schoolchildren. J Am Optom Assoc 1989;60:276–80.
15. Hayes GJ, Cohen BE, Rouse MW, De Land PN. Normative values for the nearpoint of convergence of elementary schoolchildren. Optom Vis Sci 1998;75:506–12.

16. Scheiman M, Mitchell GL, Cotter S, Cooper J, Kulp M, Rouse M, Borsting E, London R, Wensveen J. A randomized clinical trial of treatments for convergence insufficiency in children. The Convergence Insufficiency Treatment Trial (CITT) Study Group. Arch Ophthalmol 2005;123:14–24.
17. Scheiman M, Cotter S, Rouse M, Mitchell GL, Kulp M, Cooper J, Borsting E. Randomised clinical trial of the effectiveness of base-in prism reading glasses versus placebo reading glasses for symptomatic convergence insufficiency in children. The Convergence Insufficiency Treatment Trial (CITT) Study Group. Br J Ophthalmol 2005;89: 1318–23.
18. Barnhardt C, Cotter SA, Mitchell GL, Scheiman M, Kulp MT. Symptoms in children with convergence insufficiency: before and after treatment. The Convergence Insufficiency Treatment Trial (CITT) Study Group. Optom Vis Sci 2012;89:1512–20.

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