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ORIGINAL ARTICLE

A Survey of Treatment Modalities for Convergence Insufficiency

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ABSTRACT: *Background.* Convergence insufficiency (CI) is a common and distinct binocular vision disorder. However, there is a lack of consensus regarding the treatment most appropriate for CI. Possible treatment modalities include base-in prism, pencil pushup therapy (PPT), reading glasses, home-based vision therapy/orthoptics (HBVT), and office-based vision therapy/orthoptics (OBVT). The purpose of this study was to investigate the care process for CI by surveying eyecare professionals regarding the most common treatment modalities used by both optometrists and ophthalmologists across the United States. *Methods.* Surveys requesting doctors to indicate which treatment(s) they prescribed and believed to be most effective for symptomatic CI patients were mailed to 863 optometrists and 863 ophthalmologists in the United States. *Results.* Fifty-eight percent of the optometrists responded to the survey; the most common treatment prescribed was PPT (36%) followed by HBVT (22%) and OBVT (16%). For the ophthalmologists (who had a 23% response rate), the most common treatment prescribed was PPT (50%) followed by HBVT (21%) and base-in prism (10%). *Conclusions.* This survey suggests that most eyecare practitioners prescribe PPT as the initial treatment for CI. (Optom Vis Sci 2002;79:151–157)

Key Words: convergence insufficiency, survey, binocular vision disorder, vision therapy, orthoptics, exotropia, pencil push-ups

Convergence insufficiency (CI) is a common and distinct binocular vision disorder with a reported prevalence of 2.25% to 8.3% among children and adults in the United States.[1–4] Common symptoms include diplopia, asthenopia, headaches, and blurred vision during activities that require close vision (e.g., reading, computer viewing, or desk work).[5–13] The exact impact of symptomatic CI on an individual's performance at school or work, and on quality of life is unknown. Clinical signs of CI include exophoria that is greater at near than at distance, a receded near point of convergence, and reduced positive fusional vergence at near.[6]

There is a lack of consensus regarding the most appropriate treatment for CI. Various treatment modalities have been described and include base-in prism, pencil pushup therapy (PPT), reading glasses, home-based vision therapy/orthoptics (HBVT), and office-based vision therapy/orthoptics (OBVT).[14–28] Only OBVT has been extensively evaluated. Cooper and Duckman[5] (and later Grisham[29]) reviewed the literature for the years 1940 to 1987 and summarized 17 studies that included 2149 patients. They calculated a weighted cure rate of 78%, an improved rate of 15%, and a failure rate of 5%. The combined improved and cured rate was 93%. Some of these studies have been criticized because they did not clearly define the CI populations treated and because they were retrospective and uncontrolled.

There have been a few prospective, double-blind studies that have shown vergence therapy to decrease symptoms and to improve fusional vergence amplitudes in CI patients.[14–16] However, the well-controlled, double-blind studies that exist have had a small number of subjects and thus limited statistical power.

Another popular treatment consists of home-based therapy using PPT to develop increased total convergence amplitudes. Although PPT is believed to be a treatment commonly prescribed by clinicians, there has been only one clinical study evaluating its efficacy. Gallaway et al.[30] conducted a pilot study to investigate the

effectiveness of PPT as a treatment for CI. Only four of the 12 CI patients demonstrated enough of an improvement in both near point of convergence and positive fusional vergence to be classified as normal. All but one subject experienced an improvement in symptoms from PPT, although only one subject reported a total elimination of symptoms. Less than 50% of subjects completed the study, which suggests there was a problem with compliance.

Base-in relieving prisms have also been advocated as an appropriate treatment for CI. Prisms decrease the load on the vergence system and may be advantageous because they require a minimum of time from both the patient and the doctor. A potential problem with prisms is that the amount of prism appropriate for near may be inappropriate for distance, thereby necessitating two pair of glasses for the patient. Worrell et al.[31] prescribed two pair of glasses to symptomatic patients with binocular vision disorders; one set of eyeglasses included prism based on Sheard's criterion and the other set of eyeglasses had no prism. Patients were asked to wear each set of glasses for a period of time and to select the one they preferred. Patients with esophoria preferred the glasses with prism. In patients with exophoria, only presbyopic exophores wearing bifocals at near preferred the prism glasses. Long-term preference for either pair of glasses was not evaluated. Mein and Harcourt[32] suggested that base-in prism was effective for elderly patients who could not attend orthoptic therapy visits or for patients in whom orthoptics had not been successful. Lie and Opheim[33] are strong advocates for the use of prisms for CI. They prescribed prisms for 46 subjects (36 of whom had CI) and reported that symptoms were reduced and basic clinical findings were improved in all subjects.

Because symptomatic CI is a common problem that is treated with various treatment modalities, it is important to determine the mode of treatment most commonly prescribed by the ophthalmic community. Previously, Chin et al.[34] surveyed 300 optometrists in the San Francisco Bay area to determine their primary mode of treatment for CI. One hundred six (35.3%) optometrists responded to the survey. The two most commonly recommended treatments were PPT (34%) and OBVT (22%). Approximately 20% of the optometrists prescribed base-in prism, 18% referred the patient to another practitioner, and 6% did not recommend any treatment.

Because this survey evaluated the current treatment strategies of optometrists in the San Francisco Bay area only, it is difficult to generalize this study to the rest of the country since treatment may vary from region to region. In addition, the survey did not evaluate the treatment patterns of ophthalmologists. The purpose of our study was to investigate the care process for CI and the most common treatment modalities used by both optometrists and ophthalmologists across the United States.

METHODS

Mailing lists for optometrists were obtained from the American Optometric Association (AOA) and, for ophthalmologists, from the Official American Board of Medical Specialties Directory of Board Certified Medical Specialists. The ophthalmologic list allowed us to identify both general and pediatric ophthalmologists. All other subspecialties in ophthalmology were eliminated. Both the optometric and ophthalmologic lists were arranged by zip code. Using these ordered lists, a systematic sample was drawn by selecting every kth subject from the list. The sampling increment, k, was selected so that the number of subjects sampled would be approximately 800. For example, the AOA list contained slightly more than 16,000 names, so $k = 16000/800 = 20$ was used to select the sample of optometrists. We actually mailed 863 surveys to optometrists and 863 surveys to ophthalmologists. By arranging the lists by zip code, we attempted to ensure the selection of doctors from all parts of the U.S. The sample size was selected assuming a 50% response rate. With such a response rate, we expected 400 returned surveys per group, allowing us to construct a 95% confidence interval for the proportion responding in a particular fashion with a 0.05 margin of error.

Human subjects approval was obtained from the Pennsylvania College of Optometry and the State University of New York, State College of Optometry Institutional Review Boards. The survey included a cover letter describing the purpose of the survey, a case study of a symptomatic CI (Appendix 1), and a one-page questionnaire (Appendix 2) requesting the doctors to indicate which treatment(s) they prescribed and which treatments they believed to be most effective for symptomatic CI patients. Treatment options included base-in prism for reading, reading glasses (no prism), PPT, HBVT, OBVT, and no treatment (Appendix 2). To determine the clinical prevalence of CI, we also surveyed doctors with regard to the number of symptomatic CI patients they examined each month.

The surveys for the optometrists and ophthalmologists were identical, except that we substituted the term "orthoptic therapy" for "vision therapy" in the ophthalmology survey. There were three mailings to participants: an initial survey, a second survey 1 month after the first survey, and finally a postcard reminder.

Epi-Info 6.04 D (Center for Disease Control and Prevention, Atlanta, GA) was used for double data entry of both the optometric and ophthalmologic surveys. All data processing was performed using SAS 8.02 (SAS Institute, Inc., Cary, North Carolina) software. Mean number of patients (and CI patients) was compared between the two groups using a 2-sample t-test. Kruskal-Wallis test was used to determine if the number of patients or number of CI patients seen per week influenced the clinician's response concerning the use or effectiveness of each treatment option. Chi-square tests were used to compare the use and effectiveness responses given by optometrists and ophthalmologists. Follow-up comparisons controlling for the number of CI patients seen per week were performed using logistic regression analysis.

RESULTS

Table 1 summarizes the results of the survey. Fifty-eight percent of the optometrists responded to the survey. The most common treatment was PPT; 36% often or always recommended PPT, 22% often or always recommended HBVT incorporating more activities than pencil push-ups, 16% often or always prescribed OBVT, 15% often or always prescribed base-in prism glasses, and 13% often or always prescribed reading glasses. Only 3% of the respondents reported that they generally did not recommend any treatment for symptomatic CI patients. Even though only 16% of the respondents reported that they prescribed OBVT, 69% felt that this treatment was as effective or more effective than the other treatment modalities in the survey.

TABLE 1.
Comparing the use and effectiveness rating for each treatment option between ophthalmologists (MD) and optometrists (OD). Percent of each group responding in each response option is given.

Treatment	Group	Response Options				
		Never	Occasionally	Fairly Often	Often	Always
Use of base-in prism for reading	MD	33.2	48.9	8.4	6.7	2.8
	OD	21.3	48.0	16.0	12.9	1.8
Use of reading glasses (no prism)	MD	55.9	31.2	8.8	4.1	0.0
	OD	42.5	31.5	13.6	10.8	1.7
Use of pencil push-ups	MD	11.8	18.8	19.9	22.6	26.9
	OD	14.8	29.0	20.5	20.5	15.2
Use of HBVT[a]	MD	58.6	17.2	3.5	14.4	6.3
	OD	30.7	33.7	13.4	14.5	7.8
Use of OBVT	MD	74.1	13.9	6.6	5.4	0.0
	OD	60.9	18.3	4.7	10.7	5.4
Use of no treatment, monitor only	MD	43.8	39.2	9.2	7.2	0.7
	OD	59.3	32.6	4.7	2.8	0.5
Effectiveness of base-in prism for reading	MD	11.2	32.3	28.6	21.7	6.2
	OD	6.2	35.7	29.6	25.3	3.2
Effectiveness of reading glasses (no prism)	MD	37.4	39.4	16.8	6.5	0.0
	OD	31.5	35.9	17.5	13.6	1.5
Effectiveness of pencil push-ups	MD	6.3	42.6	29.0	21.6	0.6
	OD	8.7	38.6	28.5	21.5	2.7
Effectiveness of HBVT	MD	19.7	36.9	16.4	25.4	1.6
	OD	6.3	26.5	29.6	32.1	5.5
Effectiveness of OBVT	MD	21.9	31.3	20.8	24.0	2.1
	OD	8.6	15.8	17.1	41.2	17.4
Effectiveness of no treatment, monitor only	MD	40.9	46.5	7.9	4.7	0.0
	OD	59.1	33.0	4.8	3.1	0.0

[a] HBVT, home-based vision therapy; OBVT, office-base vision therapy.

Twenty-three percent of the ophthalmologists (196 total) responded to the survey. Fifty percent of the ophthalmologists often or always recommended PPT, 21% often or always recommended HBVT incorporating more activities than pencil push-ups, 5% often or always prescribed OBVT, 10% often or always prescribed base-in prism glasses, and 4% often or always prescribed reading glasses. Eight percent of the respondents reported that they did not recommend treatment for symptomatic CI patients. In contrast to optometrists, only 4% of ophthalmologists felt OBVT to be more effective than the other treatment modalities.

No statistically significant difference was found in the number of patients examined per week by the ophthalmologists vs. the optometrists who responded to the survey (30.2 patients for ophthalmologists and 27.6 patients for optometrists, $p = 0.183$). However, there was a significant difference in the number of symptomatic CI patients seen per week (0.8 patients for ophthalmologists and 1.8 patients for optometrists, $p < 0.001$). Finally, from our data we determined an estimate of the prevalence of CI in both optometric and ophthalmological practices as 7.5% and 4%, respectively.

Additional analyses were performed to compare the use and effectiveness responses given by optometrists and ophthalmologists. In all comparisons, a treatment was considered effective if

TABLE 2.
Comparing the use and effectiveness rating for each treatment option between ophthalmologists (MD) and optometrists (OD). Percent of each group responding fairly often, often, or always is reported along with the p value from the χ^2 test comparing these percentages between the two groups.

Treatment Option	Use			Effectiveness		
	MD	OD	p value	MD	OD	p value
Base-in prism for reading	18.0	30.7	0.001	56.5	58.0	0.738
Reading glasses (no prism)	12.9	26.1	<0.001	23.2	32.6	0.028
Pencil push-ups	69.4	56.3	0.002	51.1	52.7	0.716
HBVT[a]	24.1	35.6	0.006	43.4	67.2	<0.001
OBVT	12.0	20.8	0.013	46.9	75.7	<0.001
No treatment, monitor	17.0	8.0	0.002	12.6	7.9	0.106

[a] HBVT, home-based vision therapy; OBVT, office-base vision therapy.

rated fairly often, often, or always effective, and regular use of any treatment was defined as fairly often, often, or always using that treatment. As shown in Table 2, the two sets of practitioners disagreed on the regular use of all five treatment options and the effectiveness of three of the treatment options. Over 50% of respondents in both groups believed base-in prisms to be effective; however, only 18% of ophthalmologists and 31% of optometrists regularly prescribed this treatment. Reading glasses (no prism) were considered effective by 23% of ophthalmologists and 33% of optometrists, but used regularly by only 13% of ophthalmologists and 26% of optometrists. PPT was the only one of the five treatment options for which the percent of practitioners who regularly use the procedure was greater than the percent of practitioners who believed the treatment to be effective. In both groups, about half of the respondents believed pencil push-ups were effective; however, ophthalmologists were more likely to use this treatment option regularly (69% for ophthalmologists vs. 56% for optometrists).

The two groups did not agree on the use or effectiveness of HBVT and OBVT. Two-thirds of the optometrists reported that HBVT was an effective treatment for CI and 36% regularly used this treatment. On the other hand, 43% of ophthalmologists believed HBVT to be effective and only approximately 25% reported regular use. Optometrists were also more positive about the effectiveness of OBVT (76% vs. 47%); however, neither group was very likely to prescribe it regularly for CI patients. In fact, only 21% of optometrists and 12% of ophthalmologists reported regular use of OBVT.

The overall number of patients seen per week had little impact on the use or effectiveness rating given by the clinician (Table 3). The responses to the use and effectiveness of no treatment and the effectiveness of reading glasses were significantly related to the number of patients seen per week ($p = 0.0118$, 0.0018, and 0.0090, respectively). On the other hand, the number of CI patients identified per week influenced the clinician's responses concerning the use and effectiveness of four of the six treatment options (Table 3). The use and effectiveness of reading glasses, HBVT, OBVT, and no treatment were all significantly related to the number of CI patients identified per week. The more CI patients identified, the more likely the clinician was to use OBVT, HBVT, and reading glasses, and the less likely the clinician was to recommend no treatment. Neither the number of patients nor the number of CI patients influenced the clinicians' views on the use or effectiveness of base-in prism for reading or pencil push-ups.

TABLE 3.
p Values from test of relationship between number of patients and convergence insufficiency (CI) patients seen per week and response to use and effectiveness of each treatment option.

Treatment Option	Use		Effectiveness	
	No. of Patients	No. of CI Patients	No. of Patients	No. of CI Patients
Base-in prism for reading	0.0705	0.5921	0.0968	0.4283
Reading glasses (no prism)	0.2758	< 0.0001	0.0090	0.0002
Pencil push-ups	0.3394	0.8991	0.1618	0.0454
HBVT[a]	0.3939	< 0.0001	0.6947	0.0003
OBVT	0.5400	< 0.0001	0.9129	< 0.0001
No treatment, monitor	0.0118	0.0002	0.0018	< 0.0001

[a] HBVT, home-based vision therapy; OBVT, office-base vision therapy.

TABLE 4.
Adjusted odds ratios (aOR) and p values comparing the use and effectiveness rating of each treatment option between ophthalmologists and optometrists after controlling for the number of convergence insufficiency (CI) patients seen per week.

Treatment Option	Use		Effectiveness	
	aOR	p Value	aOR	p Value
Base-in prism for reading	0.45	< 0.001	0.90	0.577
Reading glasses (no prism)	0.56	0.026	0.75	0.200
Pencil push-ups	1.74	0.004	0.89	0.540
HBVT[a]	0.68	0.066	0.38	< 0.001
OBVT	0.60	0.061	0.29	< 0.001
No treatment, monitor	1.80	0.045	1.28	0.465

[a] HBVT, home-based vision therapy; OBVT, office-base vision therapy.

Logistic regression analyses controlling for the number of CI patients seen per week were performed to compare the reported use and effectiveness of each treatment between the two groups. As above, a treatment was considered effective if rated fairly often, often, or always effective, and regular use was defined as fairly often, often, or always using the treatment. The results of these comparisons are displayed in Table 4. These results indicate that the ophthalmologists are 55% less likely to use base-in prism regularly for reading, 40% less likely to use reading glasses regularly, but 74% more likely to prescribe PPT regularly, and 80% more likely to prescribe no treatment and simply to monitor the CI.

In regard to reported effectiveness of the various treatment options, the logistic regression analysis shows that optometrists are 2.6 times (1 vs. 0.38) more likely than ophthalmologists to report that HBVT is fairly often, often, or always effective, and 3.4 times (1 vs. 0.29) more likely than ophthalmologists to report that OBVT is fairly often, often, or always effective. However, the observed difference in the effectiveness of reading glasses was no longer significant ($p = 0.200$). As in Table 2, the reported effectiveness of each of the other treatment options did not differ between the groups.

DISCUSSION

Although the response rate for the optometrists was 58%, only 23% of the ophthalmologists responded to our survey. Therefore, we may not have a fully accurate measure of how ophthalmologists treat CI. This survey does demonstrate that most eyecare practitioners prescribe PPT as the initial treatment for CI. There is little difference in the distribution of other therapeutic regimens such as HBVT, OBVT, or prism prescription. Although there is a minimum of scientific support for PPT, it is easy to understand the clinical popularity of this treatment, which is both simple and cost-effective. PPT can be taught to the patient, can be prescribed

in only a few minutes, is significantly less expensive for the patient, and does not require any equipment.

Most of the optometrists surveyed believed that OBVT was the most effective treatment even though they did not prescribe it, indicating a difference between what they do and what they believe. OBVT is expensive and time consuming for the patient, and requires an equipped room and trained personnel (i.e., orthoptist or vision therapy technician). Thus, unless a clinician is committed to providing this type of therapy, it is not usually prescribed. It is also possible that the optometrists did not consider the benefit of OBVT as an offset to the financial and time commitment imposed on the patient.

We also analyzed the data to determine if there was an association between the number of patients with symptomatic CI seen and the treatment approach selected. We found some significant associations. Clinicians who treated more CI patients were more likely to report frequent use of reading glasses, HBVT, and OBVT, while clinicians with the largest mean number of patients and smallest mean number of CI patients (i.e., busy practices with few CI patients) were more likely to report use of no treatment and monitoring only. On the other hand, clinicians who reported never using the no treatment option, and perceived monitor only as a treatment option, had the largest mean number of CI patients.

Finally, we analyzed the data after controlling for the differences in the number of CI patients identified each week. These data indicated that ophthalmologists are 1.7 times more likely than optometrists to prescribe PPT and 1.8 times more likely than optometrists to prescribe no treatment and simply monitor the CI. Compared with optometrists, ophthalmologists are also less likely to recommend either HBVT or OBVT. In addition, optometrists are 3.4 times more likely than ophthalmologists to report OBVT and 2.6 times more likely than ophthalmologists to report HBVT as an effective treatment for CI.

These data can be interpreted simply to mean that clinicians who examine more CI patients are more likely to have developed expertise in prescribing and implementing both HBVT and OBVT, and more likely to consider the use of reading glasses. Another possible interpretation, however, is that clinicians with an interest in binocular vision and vision therapy are more likely to correctly identify patients with CI, whereas clinicians with less interest may perform an incomplete case history and minimum database leading to under detection of CIs in their practices. Because of the lack of interest and experience with the treatment of CI, these clinicians are less likely to have the equipment, office space, and personnel necessary to implement OBVT or HBVT for CI patients and less likely, therefore, to recommend these treatment approaches.

Prescribing PPT is appealing. If successful, the procedure can decrease symptoms in CI patients with a minimum of cost, time, and effort on the part of the patient and doctor's staff. However, the literature clearly provides more support for the use of OBVT.[5, 29] The limited use of OBVT and the belief that PPT is effective suggests that these two therapeutic interventions need to be compared in their ability to reduce or eliminate symptoms in patients with CI.

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APPENDIX 1. Case study of a symptomatic convergence insufficiency (CI) used in survey *Convergence Insufficiency Treatment Trial (CITT) Survey*

Case Study

An 18-year-old male presents with complaints of eyestrain, blurred vision, and intermittent diplopia associated with reading. These symptoms have been present for the past 12 months and occur after about 10 to 15 min of reading. There are no medical problems, he is not taking any medication, and you have ruled out any neurological/medical etiology for these symptoms. Assume that the patient is highly motivated to find a solution to his problem and is willing to comply with any treatment approach you suggest. You find the following:

Test	Results
Visual acuity at both distance and near	20/20, OD and OS
Subjective and cycloplegic refraction	OD plano, OS: plano
Near point of convergence	Diplopia at 10 inches from spectacle plane, regains fusion at 14 inches from spectacle plane
Cover test at distance	Orthophoria
Cover test at near	10–12Δ exophoria
Fusional vergence, vergence at near	Diplopia with 10Δ base-out, recovers fusion with 4Δ base-out
Accommodation	Age-appropriate accommodative amplitude and normal accommodative facility

APPENDIX 2. One-page questionnaire

1. Indicate how often you ordinarily recommend the following treatment, for symptomatic CI patients between the ages of 10 to 35 years with findings similar to the above case?

Treatment	Never	Occasionally	Fairly Often	Often	Always
Base-in prism for reading					
Reading glasses (no prism)					
Pencil push-ups*					
Home-based vision therapy**					
Office-based vision therapy***					
No treatment, monitor					

2. For the age group 10 to 35 years, with findings similar to the above case, how effective do you consider the following treatment methods to be for symptomatic CI?

Treatment	Never Effective	Occasionally Effective	Effective Fairly Often	Often Effective	Always Effective
Base-in prism for reading					
Reading glasses (no prism)					
Pencil push-ups*					
Home-based vision therapy**					
Office-based vision therapy***					
No treatment, monitor					

3. How many patients between 10 to 35 years of age do you examine each week?

4. How many patients between 10 to 35 years of age do you see each week that have symptomatic CI?

Description of Treatment Methods

*Pencil Push-Ups:	Select this category if you teach the patient how to perform pencil push-ups at home with limited follow-up care in the office.
**Home-Based Therapy:	Treatment only at home, e.g., prism, stereoscopes, or any other devices
***Office-Based Therapy:	Select this category if you satisfy both of the following criteria: (1) You schedule patients for regular office visits during which an optometrist or therapist performs therapy. (2) Your office vision therapy equipment includes most of the following: Vectograms, Tranaglyphs, stereoscopes, lenses, prisms, computer-assisted therapy procedures, chiastopic, and orthopic procedures.