# The efficacy of vision therapy for convergence excess

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## ABSTRACT

**BACKGROUND**

Convergence excess is a commonly encountered nonstrabismic ocular motility disorder. There are, however, very few research data that evaluate the effect of vision therapy for this condition in a clinical population.

**METHODS**

The records of 83 consecutive patients with convergence excess who were treated with vision therapy were reviewed to assess the impact of treatment on clinical findings and patient symptoms.

**RESULTS**

Statistically and clinically significant changes in direct and indirect measures of negative fusional vergence were seen, with 84% of patients reporting a total elimination of initial symptoms. Larger increases in negative fusional vergence were found than those previously reported. This may be a result of the more extensive and better controlled in-office treatment used in this study.

**CONCLUSIONS**

Vision therapy was successful in enhancing negative fusional vergence and eliminating symptoms in the vast majority of patients with convergence excess and should be considered an effective treatment for this condition.

**KEY WORDS**

convergence excess, vision therapy, orthoptics, esophoria, negative fusional vergence, accommodative facility

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Convergence excess (CE) is a commonly encountered nonstrabismic ocular motility disorder. Scheiman et al.[1] reported an incidence of 7.1% in a pediatric clinical population up to 18 years of age, and Hokoda[2] found that 5.9% of clinical patients under 35 years of age had symptomatic CE.

Convergence excess is defined as esophoria at near greater than at distance, and inadequate negative fusional vergence (NFV).[3] Other findings include a high AC/A ratio, a low-positive relative accommodation (PRA), reduced binocular accommodative facility, eso fixation disparity, and high lag of accommodation.[4] Patient symptoms include headaches, blur, diplopia, and asthenopia—all associated with sustained reading or near-point tasks.

Although added lenses are said to be often effective in reduction or elimination of symptoms of CE—especially in cases with a high AC/A ratio—this effect has not been studied systematically.[4] The treatment of CE with vision therapy has received some attention in the literature, but the data are quite limited. In a record review of 12 patients with CE who underwent vision therapy, Shorter and Hatch[5] found that eight of 12 patients (66%) reported improved symptoms and that five of the eight patients with complete data (62.5%) showed increased NFV. However, the changes were not statistically significant. Also, Grisham et al.[6] and Wick[7] each reported a case of CE that showed increased NFV and reduced symptoms after vision therapy.

Parks[8] studied a different population of CE patients. While the study and case reports just described used nonstrabismic CE patients, Parks investigated a sample of strabismic patients with convergence excess esotropia and compared the effectiveness of miotics or orthoptics (divergence therapy) for this population. He found that 25 of 39 of the strabismic patients (64%) treated with orthoptics showed an increase of greater than 10D in NFV.

Laird[9] found improved NFV in 16 symptomatic patients who performed 4 weeks of home training. There were not adequate data to determine

**Table 1. Mean test results, differences pre- and post-vision therapy, and tests of significance**

| | Mean (SD) pre-VT | Mean (SD) post-VT | Mean (SD) difference | t-test | Significance |
|---|---|---|---|---|---|
| **CT (D) pd esophoria (Δ)** | 0.638 (1.74) *n* = 83 | 0.482 (1.52) *n* = 83 | -0.08 (0.54) *n* = 83 | -1.22 | $p < 0.23$ NS |
| **CT (N) pd esophoria (Δ)** | 6.07 (3.04) *n* = 83 | 5.72 (4.2) *n* = 83 | -0.34 (2.98) *n* = 83 | -1.07 | $p < 0.29$ NS |
| **BI (N) blur (Δ)** | 6.67 (2.82) *n* = 15 | 12.07 (3.37) *n* = 26 | 7.5 (3.34) *n* = 8 | 6.35 | $p < 0.001$ |
| **BI (N) break (Δ)** | 8.49 (3.92) *n* = 83 | 15.94 (4.03) *n* = 83 | 7.45 (4.48) *n* = 83 | 15.13 | $p < 0.001$ |
| **BI (N) recovery (Δ)** | 3.55 (4.28 ) *n* = 83 | 12.07 (4.32) *n* = 83 | 8.52 (5.46) *n* = 83 | 14.2 | $p < 0.001$ |
| **BO (N) break (Δ)** | 21.86 (7.06) *n* = 49 | 34.33 (7.41) *n* = 49 | 12.47 (8.14) *n* = 49 | 10.72 | $p < 0.001$ |
| **BO (N) recovery (Δ)** | 15.65 (7.52) *n* = 49 | 26.61 (9.82) *n* = 49 | 10.96 (10.54) *n* = 49 | 7.28 | $p < 0.001$ |
| **BAF (cpm)** | 1.56 (3.19) *n* = 83 | 9.37 (6.35) *n* = 83 | 7.80 (6.28) *n* = 83 | 11.32 | $p < 0.001$ |

*CT* = cover test; *BI* = base in (negative fusional) vergence; *BO* = base out (positive fusional) vergence; and *BAF* = binocular accommodative facility with +2.00/-2.00.

whether these patients had CE, nor was there any statistical analysis. A number of studies have looked at the effect of training on NFV with normals. Daum[10,11] found small but statistically significant increases using conventional vision therapy, with phasic therapy producing better results than tonic. Major et al.[12] found larger increases in NFV using a computer for comparison to standard methods, and Vaegan[13] found improved NFV using a sustained base in (BI) demand. Goodson and Rahe[14] found no improvement in negative fusional vergence in normals, but they tested and trained at far point, where NFV is more limited. Griffin et al.[15] also found no change in NFV at far point using stereoscopic movies.

The purpose of the current study was to evaluate the effectiveness of vision therapy in improving NFV and resolving symptoms in patients with CE.

## Methods

For the purposes of the study, CE was defined as esophoria at near greater than or equal to 3 D, esophoria at least 3 D greater at near than distance, and reduced negative fusional vergence. Cut-off values for NFV were chosen to be greater than or equal to one standard deviation below the mean of normative values.[4] All records from patients seen in two private optometric practices over a 3-year period were reviewed. All records that met these criteria for patients with CE who subsequently underwent vision therapy were included in the study. Records were excluded only when poor patient compliance precluded the completion of the recommended number of office therapy visits. All pre- and post-therapy testing was performed by one of the two authors. The tests reported in this study consisted of standard clinical measures including history, cover test, BI vergences, and binocular accommodative facility (+2.00/-2.00 lenses). Cover testing was done with an isolated 20/30 letter at 6 M and 40 cm, and was neutralized with a prism bar. Vergence testing was performed at 40 cm with either Risley prisms in a phoropter or a prism bar, and a column of 20/30 letters.

The history was obtained through a combination of an office symptom checklist and follow-up questioning from the examiner. Because of the age of some of the subjects, it was not possible to quantify estimates of the frequency or severity of symptoms. For the purpose of this analysis, a symptom was considered present when it was either the patient's main concern or if it occurred frequently.

Vision therapy consisted of standard clinical procedures emphasizing both tonic and phasic training of NFV,[4] along with monocular and binocular accommodative rock. Instrumentation included Vectograms, Tranaglyphs, Aperture Rule, Eccentric Circles, loose prisms, Brock string, lenses, stereograms, and computerized vergence programs. The treatment sequence generally began with large peripheral targets emphasizing smooth or tonic vergence training, moved toward jump or phasic vergence training, and concluded by combining vergence and accommodative demands with detailed, central targets.[4] Vision therapy office visits were 45 minutes in length, at a frequency of once or twice a week, and home therapy was usually prescribed for 15 minutes a day, 3 to 4 times a week. Reevaluation took place after patients were able to perform Eccentric Circles, as well as clear +2.00/-2.00 lenses easily—or when their progress had reached a plateau for 3 to 4 weeks.

**Symptoms in patients with convergence excess**

| Symptoms | Frequency | Percentage |
|---|---|---|
| Blur at near | 39/83 | 47% |
| Eyestrain | 36/83 | 43% |
| Headaches | 21/83 | 25% |
| Diplopia | 21/83 | 25% |
| Poor reading comprehension | 20/83 | 24% |
| Distance blur after reading | 14/83 | 17% |
| Loss of place | 13/83 | 15% |
| Avoidance | 11/83 | 13% |
| Fatigue or sleepiness | 7/83 | 8% |
| Tearing | 3/83 | 3.6% |
| Closing one eye | 2/83 | 2.4% |

## Results

Eighty-three subjects met the criteria for inclusion in the study. The mean age of subjects was 11.8 years (SD, 4.6 years), with a range of 7 to 32 years. All but seven subjects were between the ages of 7 and 17 years. The mean number of vision therapy sessions completed was 18.5 (SD, 4.9), with a range of 9 to 32. Eighty-two percent of subjects (68 of 83) completed between 12 and 24 visits.

Table 1 lists mean values of test results pre- and post-treatment, along with the mean difference of test results pre- and post-treatment, and tests of significance. Distance and near cover test, base in blur, base in break, base in recovery, and binocular accommodative facility (BAF) were available for all 83 subjects. BI blur was recorded only if it occurred before the break. Base out (BO) break and recovery were available for 49 patients.

Statistically significant improvements with vision therapy were seen in BI blur, break, and recovery, BO break and recovery, and BAF. There was no change in distance or near cover test.

The frequency of symptoms reported before treatment are listed (*see* Box). Blurred vision at near (47%) and eyestrain when reading (43%) were the most common symptoms. Eighty-four percent of subjects reported a total elimination of symptoms and 12% said their symptoms were improved. One subject reported no improvement, and two subjects reported symptoms that they had not noted before treatment.

The subjects were divided into three groups according to their degree of initial esophoria. Group 1 was 3 to 5 D esophoria, Group 2 was 6 to 8 D esophoria, and Group 3 was greater than 8 D esophoria. Table 2 shows the results of one-way analyses of variance (ANOVAs) for changes in BI break, BI recovery, and BAF, as well as pre- and post-VT mean findings for each group. Group 3 had larger changes in BI break than Group 1 and larger changes in BI recovery than Groups 1 and 2. On BAF, Group 1 had larger changes than Group 2. The larger changes in BI break and recovery for Group 3, the subjects with the largest esophoria, are the result of lower initial BI findings than for Groups 1 and 2. The post-treatment means for each of these groups were not different than the results reported for the entire group of subjects (*see* Table 2). Also, the three groups were similar in that each achieved total elimination of symptoms in more than 80% of subjects.

## Table 2. Mean changes in test results and improvement in symptoms according to degree of esophoria

| | 3-5$^{\Delta}$ esophoria $n = 45$ | 6-8$^{\Delta}$ esophoria $n = 27$ | > 8$^{\Delta}$ esophoria $n = 11$ | F value |
|---|---|---|---|---|
| **Base in break (pd) pre-VT** | 9.27 (2.92) | 8.11 (4.73) | 5.90 (4.98) | |
| **Base in break (pd) post-VT** | 15.65 (3.70) | 16.00 (4.82) | 17.00 (3.25) | |
| **Base in break (pd)—mean change** | 6.38 (3.69)[1] | 7.89 (4.92) | 11.10 (4.94)[1] | 4.75, $p < 0.01$ |
| **Base in recovery (pd) pre-VT** | 4.53 (2.91) | 2.27 (5.33) | 0.81 (5.74) | |
| **Base in recovery (pd) post-VT** | 12.13 (4.21) | 9.82 (3.84) | 14.00 (3.09) | |
| **Base in recovery (pd)—mean change** | 7.60 (4.48)[1] | 7.55 (5.86)[2] | 13.19 (6.21)[1,2] | 5.18, $p < 0.01$ |
| **BAF (cpm) pre-VT** | 1.87 (3.18) | 1.65 (3.63) | 0 | |
| **BAF (cpm) post-VT** | 11.43 (5.92) | 7.16 (5.68) | 6.10 (6.95) | |
| **BAF (cpm)—mean change** | 9.58 (5.87)[2] | 5.57 (5.96)[2] | 6.10 (6.94) | 4.26, $p < 0.017$ |
| **No symptoms** | 87% (39/45) | 81% (22/27) | 82% (9/11) | |

[1] Significant difference exists at 0.01 level (Tukey Post-Hoc Test).
[2] Significant difference exists at 0.05 level (Tukey Post-Hoc Test).

Further analysis of subject data revealed that 32 of the subjects received a near prescription for spectacles before the onset of vision therapy, either in the form of a bifocal or single-vision reading lens. This step was taken much more often by one of the authors and reflected an attempt to achieve a quicker reduction in symptoms than with vision therapy alone. When treatment outcomes are compared, however, the group that received reading glasses at the beginning of vision therapy was no different than the group that had vision therapy alone. Table 3 shows that the changes in BI blur, break, and recovery, and BAF were not statistically different. In addition, symptomatic relief was also similar, with the no-glasses group achieving a total elimination of symptoms in 82% of cases, and the glasses group in 87% of the cases. However, the data could not answer the question as to whether there was a faster reduction in symptoms.

## Discussion

The results of this study demonstrate that vision therapy can result in both clinically and statistically significant changes in NFV, with a corresponding improvement in patient symptoms. The mean improvement in BI break was 7.57D and 8.68D for BI recovery. This result contrasts with Shorter and Hatch's[5] findings in patients with CE, and Daum's[9] findings in normals. Shorter and Hatch found a mean increase in BI break of 5D and in BI recovery of 5.1D; They only reported data on eight patients, however. Some of the subjects did mostly home therapy, and there was no continuity between pre- and post-testing because all of the patients were seen in an optometry school clinic. Daum found mean increases of 3.52D in BI break and 1.88D in BI recovery. In addition to using normals, Daum's subjects performed only 50 minutes of training per week for 3 weeks. The results of the present study suggest that larger increases in NFV are possible when the duration of treatment is longer, and when a significant portion of the treatment is administered in a controlled office environment.

For the entire group, there was no change in distance or near esophoria after treatment. The distance phoria was ortho both pre- and post-treatment in 95% (79 of 83) of subjects. The near esophoria after treatment was within 3D of the initial esophoria 86% (71 of 83

**Table 3. Mean changes in the test results and symptoms in the no near prescription group versus the near prescription group**

| | No $R_x$, N = 51 | Near $R_x$, N = 32 | t-test significance |
|---|---|---|---|
| **BI break (Δ)** | 7.43 (3.87) | 7.47 (5.38) | *t* = 0.03, NS |
| **BI recovery (Δ)** | 8.76 (5.17) | 8.12 (5.96) | *t* = -0.050, NS |
| **BAF (cpm)** | 7.35 (5.43) | 8.50 (7.50) | *t* = 0.75, NS |
| **No symptoms (%)** | 82% (42/51) | 87% (28/32) | |

*Rx* = pectacle prescription; *BI* = base in (negative fusional) vergence; and *BAF* = binocular accommodative facility.

subjects) of the time. Of the remaining patients, seven showed a decrease in esophoria of greater than 3D, and five showed an increase in esophoria greater than 3D.Two of the five patients who showed an increase revealed an additional diopter of latent hyperopia after treatment, and four of the five patients were still not able to clear -2.00 lenses binocularly. All five of these patients ended up with added lenses for near to provide maximum relief from symptoms. Persistent difficulty with minus flipper bars during treatment may be an indicator of latent hyperopia or a high AC/A and may necessitate added lenses.

After treatment, six hyperopic subjects accepted an additional +0.25D or more on a distance subjective refraction.Also, six myopic subjects had a reduction in the subjective refraction by -0.25D or more. Five subjects reported increased reading comprehension. A study by Atzmon et al.[16] found improved reading comprehension in children with reduced positive fusional vergence who received vergence training. It is possible that a similar mechanism may interfere with reading comprehension in susceptible individuals with reduced negative fusional vergence as well. In experimental situations with normal subjects, Ludlam and Ludlum[17] and Garzia et al.[18] used lenses and prisms to create stress on NFV during a reading task and found reductions in both reading speed and comprehension.

The analysis of the three groups of subjects with esophoria demonstrates that subjects with larger esophoria achieved post-treatment levels of NFV that were the same as subjects with smaller esophoria. Interestingly, the larger group showed greater changes because they were starting from lower values of NFV before treatment. Subjects with larger esophoria did manifest a trend toward smaller changes in BAF, however, probably as a result of AC/A ratios.The data support the conclusion that larger amounts of esophoria can also be treated effectively with vision therapy.

In conclusion, this study demonstrates that vision therapy is very effective in improving NFV and eliminating symptoms in patients with convergence excess. Larger increases in negative fusional vergence were found than those previously reported in patients with nonstrabismic convergence excess.This finding may be a result of the more extensive and better-controlled in-office treatment used in this study.The size of the initial esophoria is not a barrier to improvement of NFV, nor does the prescribing of added lenses change the eventual outcome. Added lenses may be helpful in patients for whom vision therapy is either not feasible or not totally successful in elimination of symptoms.Vision therapy for convergence excess should be considered an effective treatment approach either in conjunction with added lenses or as sole treatment with patients for whom lenses are not desired or practical. Additional research is needed to determine the maintenance of the treatment effect over time. It would also be helpful to compare the efficacy of added lenses alone to vision therapy.

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## Footnote

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