Reduction of Asthenopia after Accommodative Facility Training

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ABSTRACT

Five patients reporting asthenopia secondary to accommodative deficiencies underwent automated accommodative facility training. A matched-subjects, crossover design was used to control for placebo effects. All patients receiving automated accommodative training showed a marked increase in accommodative amplitude along with a concurrent reduction of asthenopia. Decreases of blur and increases of reading time were the most frequently reported changes by patients. This experiment shows the effectiveness of automated accommodative training in reducing asthenopia and improving accommodative facility.

Key Words: accommodation, accommodative infacility, accommodation insufficiency, asthenopia, blur, orthoptics, vision training

Accommodative insufficiency, ill-sustained accommodation, and accommodative inertia (accommodative infacility) are found in some nonpresbyopic patients. These conditions are often associated with blurred vision, asthenopia, reduced reading time, and loss of concentration.[1-4] Previous studies have shown that both prolonged accommodation and repetitive near-far accommodative demands produce an increase in asthenopia complaints and a decrease in accommodative amplitude in some patients.[5-8]

Traditional treatment of accommodative dysfunctions often involves orthoptic techniques.

Marg[9] and Cornsweet and Crane[10] demonstrated that voluntary accommodation and accommodative amplitude could be improved by specified training. Liu et al.[11] have shown with an infrared recording optometer that accommodative training results in an improvement in accommodative amplitude and its time constants. In the above studies, subjects who reported asthenopia initially showed a decrease of such symptoms after training. Morris[12] and Hoffman et al.[13] have suggested that approximately 85% of all accommodative anomalies (i.e., accommodative insufficiency, ill-sustained accommodation, and accommodative inertia) can be treated successfully with accommodative training; their patients reported fewer asthenopia complaints after training than before training. Recently, Daum[14,15] published a retrospective study of 96 patients with accommodative anomalies. He found that accommodative therapy improved accommodative amplitudes by at least 3.00 D and resulted in a concurrent reduction of asthenopic symptoms in 88% of the patients, whereas patients treated only with plus lenses had far fewer reductions in symptoms. Daum[14,15] concluded that accommodative training was more effective in relieving asthenopic complaints than plus lenses.

Although each of the studies cited above suggests that accommodative training can be used to improve accommodation and relieve associated asthenopia, interpretation of the results is equivocal because of various methodological deficiencies. For example, most studies failed to control for experimenter bias or placebo effects, used other concurrent treatments, or included other sources of experimental confounding. None have attempted to measure changes in asthenopia severity systematically and quantitatively by a written rating questionnaire. An earlier study by Cooper et al. did address both these issues.[16] In that study, a matched-subjects, crossover experimental design was used to assess the effect of automated fusional vergence training upon vergence ranges and asthenopia in

patients having convergence insufficiency. Results indicated that after vergence training, but not after placebo exposure, there was a significant increase in vergence ranges. This corresponded with marked reductions in patient ratings of severity of asthenopia as measured by a written questionnaire.

The purpose of the present study was to determine if systematic and programmed monocular accommodative training could be used to increase accommodative amplitudes and reduce asthenopia of patients having accommodative deficiencies. To minimize the potential contribution of the binocular vergence system to the accommodative system only mononuclar training was done. To control for experimenter bias, placebo effects, and other sources of experimental confounding as noted above, the experiment used a matched-subjects crossover design. We used a written rating questionnaire for severity of asthenopic symptoms.

METHODS

Two male and three female patients (mean age, 27 years; range, 25 to 30 years) volunteered for and completed the study. Diagnosis of an accommodative anomaly with asthenopia was made independently by at least two clinicians. Criteria for inclusion in the study consisted of each of the following: accommodative amplitude less than 5.00 D (minus lens to blur), reduced accommodative facility defined as monocular failure to clear a −2.00 D lens within 5 s, and positive relative accommodation less than 1.50 D. Each patient had to have no evidence of amblyopia, strabismus, or vergence defect (phoria greater than 4^Δ exo or 4^Δ eso; no positive or negative fusional vergence less than 20^Δ with recoveries less than 10 measured with Risley

prisms at 40 cm). Best corrected visual acuity was better than 6/9 (20/30). All patients had to have the symptoms usually associated with an accommodative anomaly such as blurred vision, asthenopia, and/or decreased reading performance. Assessment of asthenopia was by a written rating scale given to each patient (Appendix A).

Initially, each patient was given a full binocular evaluation by examiners who had no knowledge of the patient's ocular status or the group to which the patient had been assigned. The following measurements were taken: distance and near phoria; distance and near base-in and base-out ranges; accommodative amplitude via the push-up method and minus lens to blur method; monocular estimate method for lag of accommodation; base-out and base-in vectogram ranges; stereopsis on a Randot test; and accommodative facility using a ±2.00 lens. Each patient completed a 3-item questionnaire designed to rate the severity of their asthenopia. Each item was scored on a scale of 1 to 5. The asthenopia score was the summed score from the 3 questions (range 3 to 15); the higher the total score, the less the asthenopia.

After the binocular evaluation, the five patients were divided into two groups. The groups were matched as closely as possible on the basis of severity of asthenopia and accommodative anomaly. Three were assigned randomly to the experimental group and two to the control group. Each group came to the clinic twice a week for a 30-min session. The only apparatus used for accommodative therapy were two modified Keystone telebinoculars (Fig. 1). The stereoscope was modified to separate the right and left eyes. Each eye tube was enclosed to eliminate extraneous light. The telebinoculars had the +5.00 sphere prisms removed. An internal light source, with an on-off cycle of 2.5 s resulted

Fig. 1. Monocular accommodative training apparatus. Patient looks through enclosed tubes at 6/7.5 (20/25) equivalent print. Alternating light with appropriate lenses stimulate accommodation.

in alternate ocular occlusion. The viewing targets presented during the on cycle were 6/7.5 (20/25) visual stimuli. Both the control and the experimental patients received experience in identical telebinoculars, with identical viewing stimuli, during the same session time and day.

The experimental group had a plus lens placed in front of the right eye and a minus lens in front of the left eye during alternating monocular accommodative training. During the on cycle the patient was required to clear the lens interposed between the eye and the 6/7.5 (20/25) visual stimuli. After 5 min, the plus and minus lenses were switched. If the patient was able to maintain clarity for 5 min with plus and minus lenses, without any signs of ocular fatigue, the power of the next pair of lenses was increased. In addition, the patient had to demonstrate instantaneous accommodative changes. However, if the patient could clear one lens but not the other, only the lens cleared was increased according to the following sequence: +0.50/−0.50; +0.75/−1.00; +1.00/−2.00; +1.25/−3.00; +1.50/−4.00; +1.75/−4.50; +2.00/−5.00; +2.25/−5.50; +2.50/−6.00 D. By the end of twelve 30-min sessions, all patients were expected to clear a +2.50/−6.00 D within 2 s without any signs of fatigue. The final value represented 8.50 D accommodative change.

The matched control subjects underwent the same training as the experimental subjects with one exception. During each of the twelve 30-min training sessions (2 times per week for 6 weeks), the accommodative lenses marked with plus and minus values (e.g., +0.50/−0.50) were actually plano lenses. Neither the patient nor the therapist was made aware of this fact. Thus, during training, control patients experienced no altered accommodative demand. At the end of 12 sessions, both the experimental and control groups once again underwent accommodative testing, vergence testing, and the asthenopia rating questionnaire.

After this testing, the experimental patients received an additional 6 weeks of training identical to that of the control group, i.e., all training was now with plano lenses. The control group patients also received another 12 weeks of training. The conditions were identical to those of the original experimental group so that training was performed with lenses having different values of accommodative demand (e.g., +0.5/−0.5). This matched-subjects crossover design was used to control primarily for "order of treatment effects" and to demonstrate that patients switched from plano to accommodative demand lenses would show corresponding changes in accommodative amplitude and in asthenopia. After this second 12-week period, both groups again received a third clinical testing and as-

thenopia questionnaire. Once again, all evaluations were done by clinicians having no knowledge of the patient's ocular status or group, experimental or control.

RESULTS

Fig. 2 depicts the mean absolute values of accommodative amplitude during baseline, experimental, and control conditions as a function of the order of treatments. The abscissa depicts the three phases of testing, i.e., baseline, phase 1, and phase 2. Mean accommodative amplitude for all patients in each phase (determined by minus lens to blur) is plotted on the ordinate. The experimental and control groups performed similarly at the initial baseline, 5.25 and 5.08 D, respectively. However, patients who received experimental training during phase 1 showed a marked increase in accommodative amplitude compared to the control group. Amplitudes after phase 1 were 8.00 and 5.16 D, respectively. The latter value did not differ from its initial baseline measure. After phase 2, a substantial change in performance could be seen for the control group. Accommodative amplitude increased to 7.5 D for these patients, whereas it remained virtually unchanged for the original experimental group. When the data from all patients were combined so as to compare the change in accommodative amplitude after either experimental or control conditions, a statistically significant difference was observed ($t = 7.36$, $dF = 4$, $p < 0.01$).

Table 1 presents changes in accommodative amplitude for each patient after exposure to plano lenses or accommodative demand lenses. The order of assignment to groups is also indicated. As is apparent, all but one patient showed an increase in accommodative amplitude after exposure to the experimental condition that was greater than that to the control condition. Table 1 also shows that the mean change of accommodative amplitude was significantly larger after experimental than control conditions.

Fig. 3 presents the mean absolute asthenopia scores for experimental and control groups during baseline, phase 1, and phase 2 conditions. Asthenopia scores are presented on the ordinate, whereas phases of testing are presented on the abscissa. The scores during initial baseline testing were somewhat lower for the experimental than for the control group patients, 6.0 and 8.67, respectively (the higher the score, the fewer the symptoms). After phase 1, patients who received experimental training showed a marked reduction in symptoms compared to the control group, 13.0 and 9.33, respectively. The control group showed only a small change from baseline findings. After phase 2, when the original experimental and control groups received the cross-
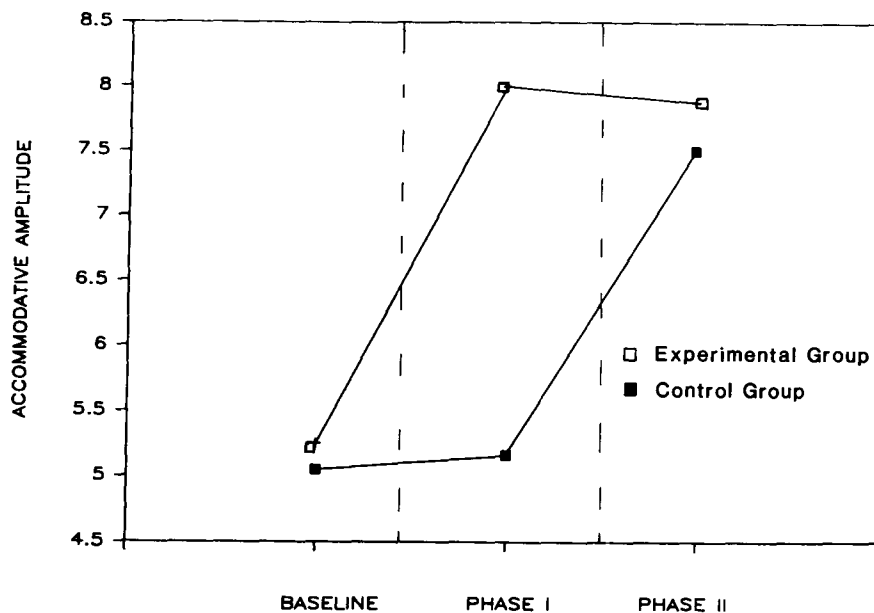
FIG. 2. The abscissa depicts the three phases of testing, i.e., baseline, phase 1, and phase 2. Mean accommodative amplitude for all patients in each phase (determined by minus lens to blur) is plotted on the ordinate. Open squares (□) represent patients who received experimental, accommodative training, during phase 1 and placebo during phase 2. Closed squares (■) represent patients who received the opposite condition, i.e., phase 1, control (placebo); phase 2, accommodative training.

TABLE 1. Accommodative amplitude change after control or experimental phases.

Patient No.	Phase 1 Group[a]	Training Phase (D)	
		Control	Experimental[b]
1	Control	0.50	2.00
2	Experimental	0.25	4.00
3	Control	1.50	2.25
4	Control	0.50	0.50
5	Experimental	−0.50	1.50
Mean change		0.45	2.05

[a] After baseline assessment, each patient experienced either a control condition or an experimental condition in the first phase (phase 1 group). Conditions in phase 2 were reversed.

[b] All change scores represent the difference in accommodative amplitude after a training condition (either experimental or control) from the immediately prior phase (i.e., baseline, control, or experimental).

over treatments, asthenopia scores improved for the control group (12.3) but remained constant for the experimental group (12.5). A sign test for ranked data[17] revealed a statistically significant difference between the effects of experimental (accommodative demand lenses) and control (plano lenses) conditions (p = 0.031) with regard to asthenopia.

Table 2 shows each patient's asthenopia change score after exposure to experimental and control conditions. The original order of group assignment is also indicated. It is apparent that every patient showed a greater improvement in asthenopia score after accommodative demand training than after placebo training. Table 2 also shows that there was virtually no change in asthenopia score after control training, whereas more than a four point change occurred after experimental training.

Before experimental training, none of the five patients were able to clear a −2.00 D lens interposed before each eye (accommodative facility). After training, four of five patients made instantaneous accommodative changes to clear both a −2.00 D lens and a +2.00 D lens. The one patient who failed to improve accommodative facility also showed minimal improvement in accommodative amplitude and in asthenopia reduction.

Analysis of phorias, refractive status, fusional ranges, stereopsis, and lag of accommodation showed no significant difference before and after accommodative therapy. Positive relative accommodation findings improved but the changes were not statistically significant, p < 10.

DISCUSSION

This study shows that monocular accommodative facility training results in an improve-
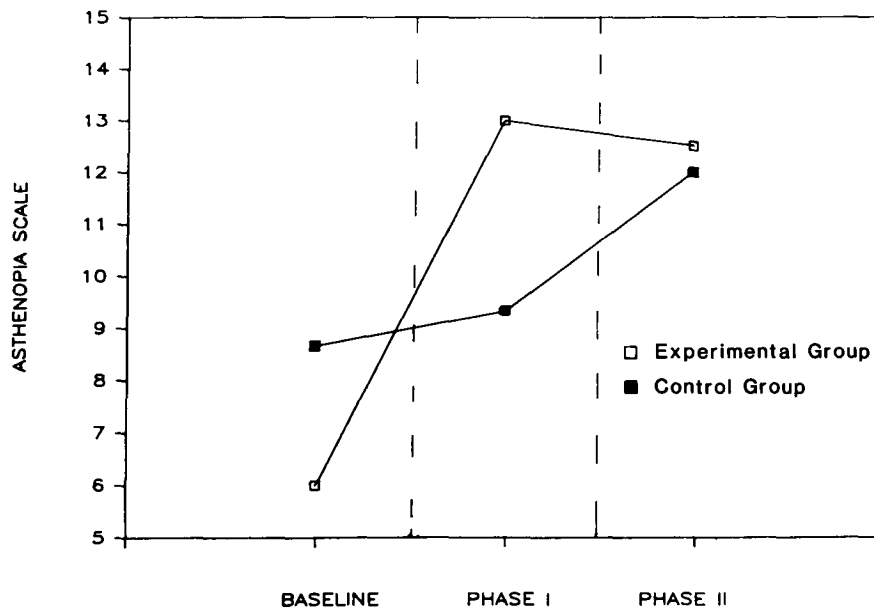
Fig. 3. Mean asthenopia scores are presented on the ordinate, whereas phases of testing are presented on the abscissa. Open squares (□) represent patients who received experimental therapy first; closed squares (■) represent those patients who received placebo therapy first.

Table 2. Asthenopia change scores after control or experimental phases.

Patient No.	Phase 1 Group[a]	Training Phase	
		Control	Experimental[b]
1	Control	3	5
2	Experimental	0	8
3	Control	1	3
4	Control	-2	2
5	Experimental	-1	5
Mean change		0.2	4.6

[a,b] See explanations given in Table 1. Scores in Table 2 represent asthenopia changes.

ment of accommodative amplitude and facility. It also indicates that asthenopia associated with accommodative anomalies can be reduced with such training. Neither the improvement in accommodative ability nor the decrease in asthenopia can be accounted for by placebo effects or experimental bias.

Previous studies have reported an 85% success rate with patients in the reduction of asthenopia after some form of accommodative training.[12-15] In our study, four of five patients also experienced a significant relief of symptoms. The one patient who did not show a decrease in symptoms also did not show much increase in accommodative amplitude or facility after training. This finding further supports the notion that

improvement in accommodative amplitude and facility is related functionally to symptom reduction.

The major changes in performance associated with accommodative training were a reduction in reported blur during reading and an increase in reading time. The asthenopia questionnaire revealed a reduction in ocular fatigue, although results were not as dramatic. Overall, the patients in this study changed from moderately uncomfortable to reasonably comfortable in a relatively short period of time.

Our primary purpose was to determine if accommodative therapy reduces asthenopia while controlling for any source of experimental bias by using a placebo control paradigm. Although a small subject sample was used, that in itself should not limit the reliability or the validity of the findings. The matched-subjects crossover control design is powerful in controlling for sources of experimental confounding and biases.[18,19] Not only are experimental and control treatments compared during the same period of time, but the control group "crosses over" to receive the experimental treatment at a later time. This replication further supports the general conclusion of the study. Appropriate statistical analyses also show that findings are unlikely to occur by chance.

This study was not designed to determine the best way to treat an accommodative anomaly. Only a single therapeutic technique was used for

the short period of 6 weeks. Typically standard accommodative therapy is practiced at home 5 days a week and continued for at least 2 months. Most patients treated that way rarely return to the office reporting the same symptoms; treatment effects appear long-lasting.

It was difficult to find patients for this study because of our requirement that they have three reduced accommodative findings without an associated vergence anomaly. Over 90% of the patients we tested in our clinic who had a primary accommodative anomaly also had an associated vergence anomaly, and thus did not meet the inclusion criteria for our study. Cooper et al.[16] have also found it difficult to identify convergence insufficiencies without an accommodative component, unless the patients were presbyopic. Most patients with ocularly related asthenopia have a combined accommodative-vergence anomaly, indicating the need for both accommodative and vergence training.

The present study did not find any improvement in stereopsis or vergence after accommodative therapy, contrary to studies by Daum.[14,15] Tentatively, our findings can be interpreted as indicating that specific monocular accommodative therapy does not transfer to these binocular abilities. It is possible to account for some of the difference between our findings and those of Daum by our use of a control group, which lessens the potential for experimenter bias and placebo effects.

In summary, earlier studies have pointed to accommodative anomalies as a source of asthenopia. Some reports[7,8] have indicated that most patients receiving repeated accommodative stimulation do not develop asthenopia. However, these investigators state that those patients who do develop asthenopia during repeated accommodative stimulation also develop accommodative fatigue. Other uncontrolled or retrospective studies[13-15] have shown that patients with accommodative related asthenopia respond to accommodative therapy if training is progressive and gradual. The present study supports these findings and we believe also demonstrates that our results are not due to experimental bias, placebo, or order effects. Rather, the reduction in asthenopic symptoms, particularly with regard to blur and reading time, appears to be a direct function of improvements in amplitude, speed, and sustaining time of accommodation.

APPENDIX A

Asthenopia Questionnaire

1. How long can you do nearwork (i.e., reading, writing, sewing, etc.) without discomfort (e.g.,

headaches, eye ache, burning, stinging, watering, blurriness, double vision, loss of concentration, or tiredness)?

   1   up to 15 min
   2   up to 20 min
   3   up to 1 h
   4   up to 2 h
   5   at least 3 h

2. How often do your eyes pull, ache or water; or do you get headaches, or does the print blur or run together after doing nearwork?

   1   every time that I read
      (100% of the time)
   2   very often
      (about 75% of the time)
   3   often
      (about 50% of the time)
   4   occasionally
      (about 25% of the time)
   5   never
      (0% of the time)

3. Immediately after prolonged nearwork, do objects at distance appear blurry?

   1   every time that I read
      (100% of the time)
   2   very often
      (about 75% of the time)
   3   often
      (about 50% of the time)
   4   occasionally
      (about 25% of the time)
   5   never
      (0% of the time)

4. Please briefly describe any other problems you have when you do nearwork. Answer on other side of paper.

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