0093-7002/87/6406-0415$02.00/0
AMERICAN JOURNAL OF OPTOMETRY & PHYSIOLOGICAL OPTICS

Vol. 64, No. 6, pp. 415–420
Printed in U.S.A.

symposium paper

Management of Binocular Anomalies: Efficacy of Vision Therapy in the Treatment of Accommodative Deficiencies

MICHAEL W. ROUSE*
Southern California College of Optometry, Fullerton, California

ABSTRACT

This paper is a review of the literature supporting vision therapy as an effective treatment mode for accommodative deficiencies. Vision therapy procedures have been shown to improve accommodative function effectively and eliminate or reduce associated symptoms. In addition, the actual physiological accommodative response variables modified by the therapy have been identified, eliminating the possibility of Hawthorne or placebo effects accounting for treatment success. Finally, the improved accommodative function appears to be fairly durable after treatment.

Key Words: vision therapy, accommodation, efficacy, binocular vision

Accommodative deficiencies are grouped typically into the following diagnostic categories[1]: (1) accommodative insufficiency; (2) accommodative infacility (inertia); (3) fatigue of or ill-sustained accommodation; (4) accommodative spasm or excess; and (5) accommodative paresis or palsy.

Accommodative paresis, spasm, and ill-sustained accommodation are relatively rare and represent only a small percentage of patients diagnosed with accommodative deficiencies.[2,3] Accommodative insufficiency and infacility are the two most common clinical conditions encountered.[3] Accommodative insufficiency represents a condition where the amplitude of accommodation is below the normal expected amplitude for the patient's age.[4] Accommodative infacility represents a condition where the patient's rate of repeatedly stimulating and inhibiting accommodation during a specific period of time (usually 1 min) is below average.[5-9]

A number of signs and symptoms have been reported to be associated with accommodative deficiencies: blur at near, intermittent blur when looking up from nearwork, headache, periods of burning, itching and/or watering of the eyes, tired eyes, double vision, loss of concentration, and avoidance of near activities.[3,6-11] Recently the incidence[8] and severity[9] of presenting complaints have been correlated positively to previous accommodative facility normative rates.[5,7] Patients presenting with symptoms demonstrated facility rates significantly lower than those without symptoms.

The treatment of functional accommodative deficiencies (where organic or toxic causes have been excluded) has included plus lens addition for nearwork or therapy aimed at strengthening the accommodative or vergence mechanism.[12-17]

The efficacy of using vision therapy techniques to "strengthen" or improve accommodative function has considerable basic scientific and clinical support.

Carr and Allen[18] and Sisson[19,20] reported on single patients who were able to demonstrate, with short periods of practice, voluntary control of accommodation. An interesting observation

---

This paper is based on an oral presentation given by Dr. Rouse on December 10, 1985 at the Symposium on Management of Binocular Anomalies: Efficacy of Vision Therapy. This meeting was sponsored by the Binocular Vision and Perception Section at the Annual Meeting of the American Academy of Optometry in Atlanta, Georgia.

Received January 5, 1987.

* Optometrist, M.S.Ed., Member of Faculty, F.A.A.O.

by Sisson was that by getting the "feel" of the act he was able to elicit voluntary accommodation without the aid of his experimental setup.

Marg[21] attempted to graph the actual accommodative response when voluntary and optical stimuli were in conflict. Patients were instructed to look closer and then further than optical stimuli placed at between 0.20 D and 5.00 D demands. Six of the 7 patients were able to exhibit large amounts of negative (inhibitory) voluntary accommodation, whereas 5 of the 7 showed positive (stimulatory) accommodation in varying degrees. A number of the patients reported symptoms with attempted positive voluntary accommodation, which Marg suggested lent support to the old clinical theory that symptoms arise from the need to exert effort to reinforce a reflex function that is inadequate. Marg demonstrated that voluntary control of accommodation was relatively common and suggested that training that facilitates it might relieve symptoms in cases with defective reflex accommodation.

Cornsweet and Crane[22] also demonstrated that voluntary control of accommodation can be developed by practice and appropriate feedback. In their experiment, the patient was wearing binaural headphones. A tone, whose pitch was controlled by the experimenter, was delivered to one ear, while the pitch of the tone in the other ear was controlled by the output of an optometer that measured the patient's accommodative response. The patient's task was to match the pitch of the tone between the two ears. The two patients were unable to do the task initially, but after a total of 3 h of ad lib. practice each of them was able to perform the task. To evaluate whether the patients could transfer the skill, the stimulus condition was changed. The patient viewed two horizontal lines on an oscilloscope screen. The vertical position of one line was controlled by the experimenter, whereas the other was controlled by the accommodative response of the patient (via optometer). Both patients could perform the task after only a few seconds of practice, thus demonstrating that the learned control of accommodation could be transferred easily to new stimulus conditions.

Randle and Murphy[23] studied the diurnal variations of accommodation by testing four college students every 3 h for 7 days. The patient's task was to track accommodatively a sine or square wave stimulus varying from infinity to 0.25 m. They found the latency of the accommodative response was stable over the 7 days. A number of patients showed higher velocity responses (D/s) with the group mean velocity increasing over the 7 days. In addition, response gain (magnitude) and phase lag (difference between stimulus and response waves) also improved over the 7 days. Randle and Murphy showed that a number of dynamic components (velocity, gain, and phase) of the accommodative response can be improved with practice. They even suggested, "It may well be that judicious training will increase the dynamic performance of accommodation and increase the useful life of the ciliary neuromuscular system."

Provine and Enoch[24] further demonstrated the learned aspect to voluntary accommodation by having patients attempt to accommodate while wearing a −9.00 D contact lens. All patients showed the capacity to learn control of nearly their entire accommodative amplitude. The training process of the patients involved the experimenters first cueing the patients to concentrate on what they experienced when they made an effort to focus upon the near target. Once the improvement began the patients rapidly learned to focus accurately, reporting the key to accomplishing the task was learning to "concentrate on" or "attend to" the task. Provine and Enoch further demonstrated the voluntary nature of the learned task by having the patients produce the accommodative response in total darkness. This indicated that the patients were using an internal performance criterion, or "feeling," and were not dependent upon visual feedback for the initiation and short-term maintenance of the accommodative response.

These studies demonstrate that voluntary control of the accommodative response can be trained and transferred to a variety of stimulus conditions. In addition the actual improved dynamic accommodative response characteristics of velocity, gain, and phase lag can be identified.

In addition to the basic science investigation of accommodative response characteristics, there are a number of clinical studies that demonstrate the effectiveness of vision therapy on a large number of patients that exhibit accommodative deficiencies.

Hoffman et al.[25] reviewed private practice records of 129 patients who had undergone vision therapy within the last 2 years. Patients with strabismic and perceptual dysfunctions were excluded. Eighty of the 129 were diagnosed initially as having either accommodative insufficiency or infacility. Most patients had a combination of accommodative and vergence problems. Patients attended two 45-min in-office visual training sessions per week and needed an average of 25 visits to eliminate all objective problems. Eighty-seven percent of the patients presenting with accommodative deficiencies were considered treated successfully. Unfortunately, changes in subjective symptoms were not reported.

Wold et al.,[26] responding to Keogh's criticism

that "It is not possible, therefore, to talk about efficacy of optometric training programs," reviewed 100 consecutive optometric vision therapy patient records. The purpose was to answer the question "Does vision therapy change visual function?" Most patients had a number of visual efficiency problems. In the area of accommodation, accommodative amplitude and facility were rated on an ordinal criterion-referenced scale of 10 points before and after therapy. Patients were seen for three 1-h office visits per week using standard optometric vision therapy procedures. The average treatment time for all patients was 35 visits. A comparison of the pre- and post-therapy ordinal scale ratings showed a significant improvement ($p < 0.001$) in accommodative amplitude and facility. Eighty percent of the patients were able to pass accommodative amplitude criterion levels after therapy compared to 39% before therapy. Similar improvements were shown with accommodative facility, with 76% passing after therapy and only 4% passing before therapy. Wold et al. demonstrated that optometric vision therapy can produce positive changes in accommodative function.

Daum[3] conducted a retrospective study of 114 patients referred to the Binocular Clinic of The Ohio State University School of Optometry and diagnosed subsequently as having accommodative dysfunction. Ninty-six percent of the patients were diagnosed as having either accommodative insufficiency or infacility. In addition to the diagnostic data, symptoms were also recorded. The most frequent symptoms noted were blur, headaches, poor facility, and asthenopia. The therapy program consisted of once a week or every other week in-office therapy combined with home therapy prescribed three times per day. Standard optometric vision therapy procedures were used. The average treatment time for the accommodative deficiencies was 3.66 weeks (range 0 to 14 weeks). For the entire group completing treatment (94), 53% achieved total success (where both objective problems and symptoms were eliminated), 43% were partially successful (where either objective or subjective problems were eliminated, but not both or when some relief was obtained in either or both categories), and only 4% obtained no relief.

These three studies, reporting on over 300 patients between the ages of 6 and approximately 40 years, demonstrate the high success rate (~80 to 90%) of optometric vision therapy in either totally or partially resolving a patient's objective accommodative deficiencies and presenting symptoms. The difference in treatment times between the three studies is probably the result of Hoffman et al.[25] and Wold et al.[26] reporting on total treatment time for all objective problems, not just accommodative problems as was reported by Daum.[3] It may also relate to the fact that Hoffman et al. and Wold et al. conducted all therapy in-office, whereas Daum reported using a combination of in-office and home vision therapy.

Duckman[27,28] reported on the high prevalence of accommodative insufficiency and/or infacility in a population of cerebral palsy patients. From earlier experiences; Duckman[28] found that accommodation could be trained in this population. Because many of the pretreatment measurements were qualitative rather than quantitative in this early study, Duckman[29] conducted a more quantitative investigation of the vision therapy results on 60 cerebral palsy children. Of the 60 children tested, 100% failed to clear a −2.00 D lens and 53% failed to clear the +2.00 D. The highest minus lens cleared, in monocular amplitude testing, was −1.50 D. Therapy consisted of standard optometric vision therapy procedures administered by trained physical and occupational therapists from 10 to 30 min a day, 3 to 4 days a week over the course of 1 year. Thirty-six children completed the therapy. Fifty-seven percent of the children could clear both the plus and minus 2.00 D lens and the mean accommodative amplitude increased to 3.09 D. Ninety-eight percent of the patients showed a significant increase in accommodative amplitude. Although the author admitted the experimental method was not optimal, the results suggest that accommodative amplitude and facility can be improved in a cerebral palsy population by using standard optometric vision therapy procedures. In addition, the teaching staff reported positive changes in performance and attention of the children as a result of the therapy program. This study suggests that vision therapy principles and procedures could be applied to other special populations for the remediation or improvement of accommodative function.

Two additional studies by Weisz[30] and Hoffman[31] lend further support to the effectiveness of vision therapy in treating accommodative deficiencies. Both these studies showed improvement in accommodative function as a result of therapy, but the major thrust was an attempt to demonstrate transfer effects of accommodative therapy on performance.

Weisz divided her 28 patients into control and experimental groups. The experimental group received accommodative therapy (two 30-min sessions per week), whereas the control group received perceptual-motor training without accommodative therapy activities (two 30-min sessions per week). A nearpoint pencil-and-paper task administered to all patients before and after the training was used to assess transfer effects on performance. All 13 experimental patients

reached normal accommodative levels within a mean of 4.5 sessions. The experimental group showed a significant decrease in the number of paper-and-pencil errors post-therapy in contrast to the control group. The implication was that accommodative training for children with diagnosed accommodative deficiencies has transfer effects upon nearpoint performance relating to improved accuracy.

Hoffman divided 48 children with primary accommodative deficiencies into experimental and control groups and administered pre- and post-therapy visual perception tests to assess any transfer effects on visual perceptual status. The experimental group received one 45-min in-office therapy visit per week combined with 15 to 20 min of daily home therapy using standard optometric vision therapy procedures, whereas the control group received daily activities unrelated to either accommodative or perceptual deficiencies. All patients in the experimental group reached acceptable levels of accommodative function with elimination of major symptoms. Treatment length ranged from 8 to 19 office visits. Post-therapy perceptual testing showed over a 60% improvement in the perceptual areas of visual discrimination and attention skills, and visual motor integration and organization for the 5- to 8-year-old experimental group. The control group showed no significant improvement. There was no significant improvement noted for either the 8- to 11- or the 11- to 13-year-old groups. The results of this study suggest that accommodative deficiencies may affect perceptual development between the ages of 5 and 8 years, and that optometric treatment of those accommodative deficiencies can result in improved perceptual performance.

These two studies both demonstrate a transfer effect upon performance, in one case paper-and-pencil accuracy and in the other perceptual discrimination and visual motor integration. An important aspect of both these studies was the use of a control population to rule out the possibility that a Hawthorne effect accounts for the differences found. The observed transfer effects are in addition to improvements in accommodative function and elimination of symptoms already noted in the literature.

Although there is considerable support for the effectiveness of vision therapy in the treatment of accommodative deficiencies, a question regarding the validity of vision therapy procedures arises because of a lack of objective evidence concerning the actual mechanisms affected during treatment. Some of the possible mechanisms or aspects of the accommodative response that may be affected were suggested by the earlier work of Randle and Murphy.[23] Two recent studies, Liu et al.[32] and Bobier and Sivak,[33] have investigated carefully the effect of accommodative therapy on the objectively monitored accommodative response.

Liu et al.[32] used a dynamic optometer to monitor, on a weekly basis, the objective accommodative response of three patients undergoing vision therapy to treat accommodative insufficiency and infacility. Each patient was prescribed standard optometric vision therapy procedures, 20 to 30 min daily. All three patients showed significant improvement in accommodative amplitude and facility and elimination or improvement of symptoms over a period of 4 to 7 weeks. Along with improvement of clinical findings and elimination of symptoms, objective changes were also noted in the optometer recordings. The most significant objective changes were in the velocity of the accommodative response to changing accommodative stimuli. Significant changes in response latency were noted in only one patient. The authors suggested "A reduction in the time constant (or increased accommodative velocity) meant a greater rate of change of the anterior curvature of the lens with increasing or decreasing accommodation; that in turn indicates greater rate of force output produced by the neuromuscular system. Reduction of the latency means a shorter reaction time of the system, which may indicate more efficient signal processing at the cortical level. Reduction of either time constant or latency results in a more rapid focusing of the target."

Bobier and Sivak[33] conducted a similar investigation using dynamic photorefraction to measure relative changes in the accommodative response. Five patients diagnosed as having accommodative infacility were prescribed standard optometric procedures to be done 20 min a day at home. Dynamic photorefraction measurements and clinical findings were taken weekly. The results showed good correlation between improved speed of the accommodative response on the clinical findings and improved time characteristics, latency, and velocity, as measured by photorefraction. Bobier and Sivak's results confirmed the previous work of Liu et al.

These two studies show a good correlation between the improvement in clinical findings (objective and subjective) and changes in the objectively measured dynamics of the accommodative response. The results strongly support the efficacy of optometric vision therapy in the treatment of accommodative deficiencies and eliminate the possibility that patient improvement is simply the result of a placebo effect.

One question remaining relates to the durability of improved accommodative function. Bobier and Sivak[33] noted no significant regressions for two patients tested several weeks (one patient 18 weeks later) after therapy. Daum[3]

showed follow-up mean accommodative amplitude data on 24 patients. The mean amplitude had fallen approximately 2 D (from 12 to 10 D) but was still significantly higher than pretherapy levels of 8 D. These studies suggest that the accommodative function improvements are fairly durable.

SUMMARY

The literature provides a solid base of research supporting vision therapy as an effective treatment mode for accommodative deficiencies. Vision therapy procedures have been shown to improve accommodative function effectively and to eliminate or reduce associated symptoms. In addition, the actual physiological accommodative response variables modified by the therapy have been identified, thus eliminating the possibility of Hawthorne or placebo effects accounting for treatment success. Finally the improved accommodative function appears to be fairly durable after treatment.

Future research might be directed into one or more of the following areas: additional longitudinal studies evaluating the durability of accommodative improvements; recurrence rates of subjective signs and symptoms; transfer effects of improved accommodative function on performance tasks; treatment effects on older prepresbyopic (ages 30 to 39 years) and even early presbyopic age groups; and comparison of the treatment effectiveness of different vision therapy procedures and/or regimens.

REFERENCES

1. Abrams D, ed. Duke-Elder's Practice of Refraction. 9th ed. New York: Churchill Livingstone, 1978:68–71.
2. Prangen A. Spasm of accommodation with report of 30 cases. Transactions of the Section on Ophthalmology of the American Medical Association of the 82nd Annual Session, AMA Press, 1922:282–92.
3. Daum KM. Accommodative dysfunction. Doc Ophthalmol 1983;55:177–98.
4. Borish IM. Clinical Refraction. 3rd ed. Chicago: Professional Press, 1970:149–88.
5. Burge S. Suppression during binocular accommodative rock. Optom Mon 1979;70:867–72.
6. Schlange D, Kostelink K, Paterson D, Wild R. Accommodative facility: a normative study. Unpublished paper, available from Carl F. Shephard Memorial Library, Illinois College of Optometry, Chicago, IL. 1979.
7. Zellers JA, Alpert TL, Rouse MW. A review of the literature and a normative study of accommodative facility. J Am Optom Assoc 1984;55:31–7.
8. Hennessey D, Iosue RA, Rouse MW. Relation of symptoms to accommodative infacility of school-aged children. Am J Optom Physiol Opt 1984;61:177–83.
9. Levine S, Ciuffreda KJ, Selenow A, Flax N. Clinical assessment of accommodative facility in symptomatic and asymptomatic individuals. J Am Optom Assoc 1985;56:286–90.
10. Hofstetter HW. An ergographic analysis of fatigue of accommodation. Am J Optom Arch Am Acad Optom 1943;20:115–35.
11. Hoffman LG, Rouse MW. Referral recommendations for binocular function and/or developmental perceptual deficiencies. J Am Optom Assoc 1980;51:119–25.
12. Duane A. Anomalies of accommodation clinically considered. Arch Ophthalmol (Old Series) 1916;45:124–36.
13. Duane A. Subnormal accommodation. Arch Ophthalmol (Old Series) 1925;54:566–87.
14. Prangen A. Subnormal accommodation. Arch Ophthalmol 1931;6:906–18.
15. Berens C, Connolly PT, Kern D. Certain motor anomalies of the eye in relation to prescribing lenses. Am J Ophthalmol 1933;16:199–213.
16. Prakash P, Agarwal L, Nag S. Accommodational weakness and convergence insufficiency. Orient Arch Ophthalmol 1972;10:261–4.
17. von Noorden G, Brown D, Parks M. Associated convergence and accommodative insufficiency. Doc Ophthalmol 1973;34:393–403.
18. Carr H, Allen JB. A study of certain relations of accommodation and convergence to the judgement of the third dimension. Psychol Rev 1906;13:258–75.
19. Sisson ED. A case of voluntary accommodation. J Gen Psychol 1937;17:170–4.
20. Sisson ED. Voluntary control of accommodation. J Gen Psychol 1938;18:195–8.
21. Marg E. An investigation of voluntary as distinguished from reflex accommodation. Am J Optom Arch Am Acad Optom 1951;28:347–56.
22. Cornsweet TN, Crane HD. Training the visual accommodative system. Vision Res 1973;13:713–5.
23. Randle RJ, Murphy MR. The dynamic response of visual accommodation over a seven-day period. Am J Optom Physiol Opt 1974;51:530–44.
24. Provine RR, Enoch JM. On voluntary ocular accommodation. Percept Psychophys 1975;17:209–12.
25. Hoffman L, Cohen AH, Feurer G. Effectiveness of nonstrabismus optometric vision training in a private practice. Am J Optom Arch Am Acad Optom 1973;50:813–6.
26. Wold RM, Pierce JR, Keddington J. Effectiveness of optometric vision therapy. J Am Optom Assoc 1978;49:1047–54.
27. Duckman RH. The incidence of visual anomalies in a population of cerebral palsied children. J Am Optom Assoc 1979;50:1013–6.
28. Duckman RH. Effectiveness of visual training on a population of cerebral palsied children. J Am Optom Assoc 1980;51:607–14.
29. Duckman RH. Accommodation in cerebral palsy: function and remediation. J Am Optom Assoc 1984;55:281–3.
30. Weisz CL. Clinical therapy for accommodative responses: transfer effects upon performance. J Am Optom Assoc 1979;50:209–16.
31. Hoffman LG. The effect of accommodative deficiencies on the developmental level of perceptual skills. Am J Optom Physiol Opt 1982;59:254–61.
32. Liu JS, Lee M, Jang J, Ciuffreda KJ, Wong JH, Grisham D, Stark L. Objective assessment of accommodative orthoptics. I. Dynamic insufficiency. Am J Optom Physiol Opt 1979;56:285–94.
33. Bobier WR, Sivak JG. Orthoptic treatment of subjects showing slow accommodative response. Am J Optom Physiol Opt 1982;60:678–87.

AUTHOR'S ADDRESS:
Michael W. Rouse
Southern California College of Optometry
2575 Yorba Linda Blvd.
Fullerton, California 92631