The Effectiveness of Vision Therapy

in Improving Visual Function

Report by the American Optometric Association

Documentation on the Clinical Research and Scientific Support Underlying Vision Therapy

What is Vision Therapy? Oculomotor/Tracking Skills Binocular Vision/Eye Teaming Summary
Who can benefit? Accommodation/Focusing Binocular Vision/Strabismus References

Note: There is a tremendous amount of literature available which documents the effectiveness of vision therapy in treating binocular vision (eye coordination and alignment), oculomotor (tracking and eye movements), and accommodative (focusing) problems. The following is a copy of a report published by the American Optometric Association entitled "The Efficacy of Vision Therapy." Please note over two hundred references listed at the end of the paper. The clinical research, scientific studies, and professional articles listed in the bibliography were first published in "refereed" scientific journals, meaning each were examined by outside experts before publication to validate their science, value, and research methodology.

Please refer to the ***Bibliography of Research*** *for a more complete list of studies and clinical reports underlying the science supporting vision therapy.*

"The Efficacy of Optometric Vision Therapy"

The purpose of this paper is to offer supporting documentation for the efficacy and validity of vision therapy for modifying and improving vision functioning.

Optometry is an independent primary health care profession. Its scope of practice includes the prevention and remediation of disorders of the vision system through the examination, diagnosis, treatment, and/or management of visual efficiency and eye health as well as the recognition and diagnosis of related systemic manifestations, all of which are designed to preserve and enhance the quality of our lives and environment.

Optometrists examine the eyes and related structures to determine the presence of vision problems, eye disease, and other abnormalities. They gather information on the vision system during the optometric examination, diagnose any conditions discovered, and prescribe individual or combinations of interventions such as corrective lenses, prescription drugs, contact lenses, and vision therapy.

The American Optometric Association considers vision therapy an essential and integral part of the practice of optometry (1). Forty-three states specifically describe vision training, orthoptics, or some synonym in their definitions of the profession of optometry .The Institute of Medicine of the National Academy of Sciences (2), the Dictionary of Occupational Titles of the Employment and Training Administration (3), the U

.S. Public Health Service (4), the U.S. Dept. of Labor, Employment and Training Administration (5), the National Center for Health Statistics (6), the Bureau of Labor Statistics (7), The Dept. of Health and Human Services (8) and the Association of Academic Health Centers (9) all include vision therapy in their definitions of the profession of optometry.

The theory and procedures underlying the diagnosis and management of vision disorders are taught in all the schools and colleges of optometry (9). In addition, the National Board of Examiners in Optometry (10) and the majority of the various state licensing agencies examine applicants for their theoretical and clinical knowledge in vision therapy.

What is vision therapy / visual training?

Vision therapy (also called vision training, orthoptics, eye training, and eye exercises) is a clinical approach for correcting and ameliorating the effects of eye movement disorders, nonstrabismic binocular dysfunctions, focusing disorders, strabismus, amblyopia, nystagmus, and certain visual perceptual (information processing) disorders. The practice of vision therapy entails a variety of non-surgical therapeutic procedures designed to modify different aspects of visual function (11). Its purpose is to cure or ameliorate a diagnosed neuromuscular, neurophysiological, or neurosensory visual dysfunction.

Vision therapy typically involves a series of treatments during which carefully planned activities are carried out by the patient under professional supervision in order to relieve the visual problem. The specific procedures and instrumentation utilized are determined by the nature and severity of the diagnosed condition. Vision therapy is not instituted to simply strengthen eye muscles, but rather is generally done to treat functional deficiencies in order for the patient to achieve optimal efficiency and comfort.

The treatment may appear to be relatively uncomplicated, such as patching an eye as part of amblyopia therapy. Or, it may require complex infrared sensing devices and computers, which monitor eye position and provide feedback to the patient to reduce the uncontrolled jumping of an eye with nystagmus. Treatment of strabismus, or turned eye, can involve complex optical and electronic instruments or such simple devices as a penlight or a mirror. The particular procedures and instruments are dependent on the nature of the visual dysfunction and the doctor's clinical judgment.

Who can benefit?

Vision therapy is utilized for conditions, which include oculomotor dysfunctions, non-strabismus binocular coordination problems, accommodative disorders, strabismus, amblyopia, and nystagmus.

These disorders and dysfunctions have a prevalence rate second only to refractive conditions, such as myopia and hyperopia, and are far greater than most ocular diseases (12-16). Graham (17) reports overt strabismus in almost 4% of over 4,000 school children. Among clinical cases, Fletcher and Silverman (18) found 8% of 1,100 to be strabismic. Other studies have generally found rates between these two levels (19).

The reported prevalence of amblyopia varies somewhat depending upon the specific criteria used, with low estimates at approximately 2% (20), and ranging up to 8.3% in the Rand HIE report (21), and also in the study by Ross, Murray and Steed (22). The National Society to Prevent Blindness estimates 127,000 new cases of amblyopia per year in the United States (23).

Non-strabismic binocular coordination anomalies have an even higher incidence. Convergence insufficiency is reported in 15% of adults by Duke-Elder (24). Graham (l5) reports high heterophorias in over

13%, while Hokoda (25) found fusion or accommodative problems in 21% of a non-presbyopic clinical population. The recently developed New York State Vision Screening Battery probes oculomotor, binocular, accommodative, and visual perceptual function. Testing of 1,634 children with this battery revealed a failure rate of 53% (27).

When "special" populations are considered, the incidence of ocular coordination and visual processing problems becomes very high. Among children who are reading disabled, as many as 80% show deficiency in one or more basic visual skills (26). Grisham (28) has recently reported that children with reading problems showed greater than a 50% prevalence of visual deficiencies in accommodation, fusional vergence or gross convergence, compared to their normally achieving peers. Cerebral palsied patients show an incidence of strabismus as high as 50%. (29,30)

The hearing impaired (31.32), emotionally impaired (33), and developmentally disabled (34,35) also demonstrate unusually high prevalence rates of visual problems. This is of particular importance because almost 11% of the school population has been identified as having one of the above handicapping conditions (36).

Our culture continues to foster higher educational standards and produces work related tasks, which are increasingly visually demanding. This is evident in the difficulties encountered by video display terminal (VDT) operators. A majority of surveys have shown that more than 50% of VDT workers report they experience some type of ocular discomfort or blurring (37,38). The National Academy of Sciences (39) concluded that the oculomotor and binocular vision changes noted at video display terminals are similar to those that occur during standard nearpoint tasks.

What are oculomotor skills and oculomotor dysfunctions? [Tracking and eye movements]

Clear vision occurs when a precisely focused image of the object of regard is centered on the fovea and when accurate eye movements maintain this relationship. The components of the oculomotor or eye movement system include fixations, vestibular and optokinetic movements, saccades, and pursuit movements (40).

Each one of the components has its own distinct and different neuroanatomical substrate and functional neurophysiology (41). There are times when several components interact. An example of this occurs when the pursuit system interacts with other systems to create the ocular stabilization or position maintenance system (42) to hold the eyes steady.

Nystagmus, a to-and-fro involuntary movement of the eyes, is caused by disturbances in the mechanisms that hold images steady (position maintenance) and may be exhibited in over a dozen different clinical patterns of movement (43). This loss of ability to maintain central fixation and eye position with the foveal area is one of the characteristics of pathological nystagmus.

Patients with amblyopia represent another class of individuals with impaired central fixational ability. Lack of ability to steadily fixate with the fovea is accompanied by reduced visual acuity and is commonly observed in anisometropic and especially strabismic amblyopes. Their characteristics have been described extensively (44-46). Abnormal saccadic and pursuit eye movements are exhibited in strabismic amblyopes and appear to be related to dysfunctions in the monocular motor control center for position maintenance (47-49).

When nystagmus or nystagmoid movements are present, the clinical identification of fixation pauses, regressions, and progressions during reading become difficult. The erratic eye movements interfere with efficient visual information processing (50,51).

During reading, the function or behavior of the eye movement system involves more than the physical movement of the eyes alone. This functional component involves the integration of the eye movements with higher cognitive processes including attention, memory, and the utilization of the perceived visual information (52).

Clinical and research evidence strongly suggest that many children and adults who have difficulty with both reading and non-reading visual information processing tasks exhibit abnormal eye movements (53-66).

Numerous studies (67-69) indicate that there is a distinct difference in the oculomotor (eye movement) patterns between children with reflective strategies or styles of processing visual information and those with impulsive styles. There is evidence that children and adults with attentional difficulties and hyperactivity exhibit inefficient eye movement patterns that interfere with visual information processing (70-74).

In summary, there are a variety of dysfunctions in the oculomotor system. Their clinical manifestations are quite often related to problems with functional visual performance and the efficient processing of information.

Can eye movement skills be modified?

Improvement in eye movement control and efficiency has been reported in individual case studies following vision therapy (75-77).

Wold et al (78) reported on 100 consecutive optometric vision therapy patients whose eye movement skills were rated on the Heinsen-Schrock Performance Scale (79). This is a 10-point observational scale for scoring saccadic and pursuit eye movement performance. Only 6% of the children passed the eye movement portion prior to therapy. Post-therapy reevaluation revealed that 96% of the children were able to pass.

Heath (80) discussed the influence of ocular-motor proficiency on reading. Sixty third and fourth graders who scored below the 40th percentile on the Metropolitan Reading Test and failed the ocular pursuit subtest of the Purdue Perceptual Motor Survey were divided into control and experimental groups. Results of the study showed significant improvement in ocular pursuit ability for the experimental compared to the control group. In addition, those children receiving therapy were found to score significantly better on a post-test of the Metropolitan Reading Test.

Fujimoto et al (81) compared the use of various techniques for saccadic fixation training. In this controlled clinical trial, both of the treated groups showed a statistically significant improvement in speed and accuracy of eye movements compared to an untreated control group.

A controlled study of pursuit eye movements was conducted by Busby (82) in an enhancement program for special education students. The subjects were rated on their ability to maintain fixation on a moving target. The rating procedure was shown to have a high interrater reliability. The results showed statistically significant improvement by the experimental group in pursuit eye movement and persistence of the therapeutic effect on retesting at a 3-month interval after conclusion of the therapy.

Punnett and Steinhauer (83) conducted a controlled study investigating the effects of eye movement training with and without feedback and reinforcement. There were clear post-training differences between the eye movement skills of the control and experimental group of reading disabled students. This demonstrated that the use of reinforcement in training oculomotor facility could improve those skills. There was an improvement in reading performance following the oculomotor training as well. Similar results demonstrating the trainability of eye movements have been obtained in studies employing behavior modification and reinforcement (84,85).

Modifying and improving the oculomotor ability to maintain central fixation and eye position in nystagmus patients has been reported over the years in various studies.

The use of after-images (86,87) and Emergent Textual Contour training to provide visual biofeedback regarding eye position and stability has had some success in improving fixational ability. Orthoptics, as well as verbal feedback techniques, have helped some patients in reducing their nystagmus (88-90).

More recently, the application of eye movement auditory biofeedback in the control of nystagmus has shown positive results. Ciufredda et al (91) demonstrated a significant reduction in the amplitude and velocity of eye movements in congenital nystagmus patients. Vision was improved, and positive cosmetic and psychological changes were reported as well. Abadi et al (92) reported reduction in nystagmus and improvement of contrast sensitivity after auditory biofeedback training. In addition to nystagmus, the use of auditory biofeedback has been successfully used in expanding the range of eye movement in gaze limitations (93).

There is evidence (94) that large and unsteady eye movements occur in the eyes of amblyopic patients during attempted monocular fixation. A number of studies report the successful treatment of amblyopia resulting in improved vision and oculomotor control (95-98). Occlusion therapy, a passive procedure, has been a standard and relatively successful approach for many years (99-111). However, there are individuals that either do not or cannot respond to occlusion therapy. There is evidence that occlusion with active vision therapy is more effective than occlusion alone (112). Pleoptics (113,114) is an active vision therapy procedure in which patients receive visual feedback about their position of fixation and direction of gaze. These procedures are designed to correct the positional fixation problem and thereby improve the vision of the patient. Pleoptics has been used successfully in treating eccentric fixation in individuals not responding to regular occlusion therapy (115-118).

Vision therapy for amblyopia incorporates a broad spectrum of procedures, including occlusion techniques, pleoptic techniques, and visual-motor spatial localization feedback techniques using after-images and entoptic phenomena (45,79) with a high success rate (119-124).

The question of age and its influence on the efficacy of amblyopia therapy has been addressed in a number of studies and reviews. These indicate that a significant improvement in oculomotor and vision function can be achieved even in adulthood (125). It is clear from the evidence that amblyopia and its oculomotor components can be successfully treated with occlusion and active vision therapy for a wide range of patients of all ages.

Studies have demonstrated that it is possible to change and improve inefficient and inadequate visual information processing strategies and visual attention patterns. Many of these changes have been accompanied by enhanced eye movements (126-138).

A number of techniques used to improve these poor visual scanning and attention problems in children and adults, e.g., tachistoscopic procedures, pursuit and fixation activities, and eye-hand coordination techniques have been described and utilized professionally for many years (79,139-143).

What are accommodative dysfunctions and their remediation? [Focusing]

Accommodative (focusing) dysfunctions have been described in detail (144-146) in numerous sources and are clinically classified as accommodative spasm, accommodative infacility, accommodative insufficiency, and ill-sustained accommodation. There are also clearly defined syndromes associated with accommodative dysfunctions (147-155).

The literature discusses many symptoms common to accommodative dysfunctions as a group. These have been described as reduced nearpoint acuity, a general inability to sustain nearpoint activity, asthenopia, excessive rubbing of the eyes, headaches, periodic blurring of distance vision after prolonged near activities, periodic double vision at near, and excessive fatigue at the end of the day (152,154,156-160).

The efficacy of applying vision therapy procedures in improving accommodative functioning has considerable basic science and clinical research support. Studies have shown that accommodative findings, although under autonomic nervous system control, can respond to voluntary command (161-163) and can be conditioned (164). These studies demonstrate that voluntary control of accommodation can be controlled, trained, and transferred.

Once pathological or iatrogenic causes have been eliminated, the treatment of accommodative deficiencies includes plus lenses for near work and vision therapy aimed at improving the functioning of the accommodative mechanism (165-168). Levine et al (156) established baseline statistics for diagnostic accommodation findings which differentiate symptomatic from asymptomatic patients. Their findings were in close agreement with a similar study by Zellers and Rouse (152). The significant element of these studies is the relationship between symptoms and inadequate accommodative facility.

Wold (78) reported on 100 children who had undergone accommodative vision therapy procedures. These clinically selected cases showed an 80% rate of improvement in accommodative amplitude and 76% in accommodative facility using a pre- and post-treatment ordinal criterion referenced scaling method. These results are similar to those reported by Hoffman and Cohen (168) a in which 70 patients were successfully treated for accommodative insufficiency and infacility based on clinical findings.

Liu et al (169) investigated accommodative facility disorders by objective laboratory methods using a dynamic optometer with an infrared photomultiplier. They objectively identified the dynamic aspects of the accommodative response that were improved by vision therapy. Young adults with symptoms related to focusing difficulties were treated by procedures commonly used in orthoptic or vision therapy practice. Significant improvement in their focus flexibility occurred and these changes correlated with marked reduction or elimination of symptoms. Standard clinical measures of accommodative facility were found to correlate well with the more objective measures.

Bobier and Sivak (l70) replicated the work of Liu et al (169) using a greater degree of recording precision with a dynamic photorefractor (television camera and monitor with light-emitting diodes}. They found no evidence of regression in improved focusing flexibility during an l8-week interval after cessation of training. The subjects' symptoms also abated as accommodative function normalized. Hung et al (l71) demonstrated the efficacy of accommodation, vergence, and accommodative vergence orthoptic therapy using a dynamic binocular simulator. This experiment objectively validated optometric vision therapy procedures through use of photoelectric eye movement recording systems and an optometer.

There is a higher prevalence of accommodative insufficiencies and infacilities in persons with cerebral palsy (172). Duckman demonstrated that accommodative abilities can be modified and improved in a cerebral palsy population using vision therapy techniques (173,174).

Since accommodative changes take place when looking from near to far and back to near, Haynes and McWilliams (175) investigated the effects of training this near-far response on school age and college students. Their results indicate that this near-far response ability is trainable and can be improved with vision therapy.

Weisz (l76) has shown that improvement in accommodative ability transfers to improvement in near point task performance. In a double blind clinical study following vision therapy, her experimental group was found to improve significantly in accuracy of performance on a Landolt-C resolution task as compared with the controls.

Hoffman (160) investigated the impact of accommodative deficiencies on visual information processing tasks. He compared the results of vision therapy for the accommodative problems in an experimental and control group of school age children. This study indicated that by improving accommodative skills, there was a concomitant improvement in his subject's visual perceptual skills.

Recently, in a detailed series of analyses involving retrospective studies, Daum (177-180) investigated the full range of accommodative disorders. He used a stepwise discriminant analysis of regression variables in patient care records, to establish a model to determine the length of treatment necessary, and to predict the success of treatment for accommodative disorders.

In conclusion, these studies demonstrate that accommodative disorders can cause significant discomfort, inefficiency or avoidance of nearpoint tasks. They further demonstrate that when diagnosed and treated appropriately, these dysfunctions may be ameliorated or eliminated through vision therapy.

What are binocular vision disorders and their remediation? [Eye coordination and alignment]

Normal and efficient binocular vision is based on the presence of motor alignment and coordination of the two eyes and sensory fusion. The range of binocular disorders extends from constant strabismus with no binocular vision present to non-strabismic binocular dysfunctions, e.g., convergence insufficiency (146).

The first category is non-strabismic binocular disorders. Standard techniques and diagnostic criteria in the assessment of the vergence system and binocular sensory fusion ability have been described in detail elsewhere (181-185).

Patients exhibiting non-strabismic anomalies of binocular vision quite often report feeling ocular discomfort and asthenopia (186). Some of the patient complaints include eyestrain, soreness of the eyes, frontal and occipital headaches, and ocular fatigue which result in an aversion to reading and studying (187,187a).

Vision therapy has long been advocated as a primary intervention technique for the amelioration of non-strabismic anomalies of binocular vision (188-194). Suchoff and Petito (l46) have concluded that vision therapy for these conditions is directed toward several therapeutic goals: First, to increase the efficiency of the accommodative system so as to facilitate a more effective interaction between this system and the vergence system. Second, to maximize the functioning of the fusional vergence system (i.e., divergence and convergence) and the binocular sensory system. Since the training of accommodation has been covered in the previous section, the remainder of this section will be devoted to the evidence of the modifiability of the vergence system.

Clinical vision therapy procedures are intended to improve the patient's ability to compensate for fusional stress which may result in asthenopia, headache, and/or diplopia. A number of studies will be reviewed showing that improvements can be made in fusional vergence skills by vision therapy procedures.

The clinical assumption that fusional vergences can be trained is not a new one. Over 50 years ago, Berens et al advocated the use of this aspect of orthoptics for all non-strabismic anomalies of binocular vision (195). Within the past several years a number of investigators have sought to determine experimentally whether the clinical assumption of the trainability of the vergence system was a valid one.

Daum (196) prospectively studied a group of 35 young adults. The results of daily vision therapy showed statistically significant improvement in convergence ranges. The gains persisted on post-testing 24 weeks after completion of the therapy program. The conclusion was that relatively short periods of training can provide long-lasting increases in vergence ability.

Daum (l97) conducted a retrospective study of 110 patients who received treatment for convergence insufficiency. The patients were classified according to the effectiveness of the treatment program into total success, partial success or no success categories. Post training diagnostic findings and changes in patient symptomatology were used to define the classification categories. A comparison of pre- and post-training findings revealed statistically significant improvement. In a companion report, (198) a portion of the above data (l97) was used to investigate and identify which of 14 common diagnostic measures best predicted the success of the vision training program. These measures were 75% accurate in predicting efficacy of the vision therapy program.

Another study (l99) utilized tonic and phasic vergence training and demonstrated impressive changes in convergence and divergence abilities. The 34 subjects were randomly assigned in a double crossover design, wherein subjects served as their own controls, and learning effects were controlled.

In another study, Veagan used a motor-driven prism stereoscope (ophthalmic ergograph) to train divergence and convergence (200). Forty- seven adults were divided into convergence and divergence experimental and control groups. The findings led Veagan to conclude that sustained divergence and convergence training showed large and significant immediate and stable improvement in the trained vergence ranges of the experimental groups.

Vaegan and McMonnies (201) utilized a recording device that measured eye movements during vergence activity. They were able to objectively demonstrate that convergence training with prism-induced changes resulted in sustained improvement of convergence ability. In a companion study, Vaegan (202) demonstrated substantial long-lasting gains in convergence and divergence ability from both tonic and phasic vergence training.

Pantano (203) studied over 200 subjects with convergence insufficiency who underwent vision therapy and evaluated them 2 years later. The majority remained asymptomatic with normal clinical findings. Those subjects who had learned to control convergence and accommodation together had the best success.

Grisham (204, 205) used vergence latencies, velocity, and step vergence tracking rate by measuring them objectively with infra-red eye monitor recordings; He reported improved step vergence tracking after vision therapy of 4 to 8 weeks.

Cooper and Duckman, in their extensive review of convergence insufficiency, stated that 95% of the patients reported in these studies responded favorably to vision therapy for this binocular disorder (206).

Cooper and Feldman (207) investigated the role and clinical use of operant conditioning in vision therapy based on random dot stereograms (RDS). They demonstrated that response-contingent positive reinforcement, immediate feedback, and preprogrammed systematic changes during discrimination learning improves convergence ability. Control and experimental groups were formed with subjects matched in baseline convergence ability and randomly assigned to each group. The convergence ranges of the experimental group improved significantly while there were little or no increases for the control group.

Cooper et a1 (208) conducted a controlled study of vision therapy and its relationship to symptomatology for a group of patients with convergence insufficiency. A vision therapy program of fusional vergence activities was administered in a matched-subjects control group crossover design to reduce placebo effects. They used a written assessment scale for rating asthenopia in terms of discomfort and/or fatigue, and conclusively demonstrated that the symptoms were eliminated or relieved. Clinical findings also improved, corroborating the subjective assessments.

Dalzie1 (209) reported on 100 convergence insufficiency patients who did not meet Sheard's criterion, and were given a program of vision therapy. After vision therapy, clinical findings were again assessed and 84% of the patients successfully met Sheard's criterion. Eighty-three percent of the patients reported they had symptoms of discomfort or loss of efficiency prior to treatment. Only 7% reported these symptoms after therapy. The post-training group who failed to meet Sheard's criterion correlated well with those still reporting subjective symptoms.

Wold (78) reported on the results of 100 patients who underwent vision therapy. Based on standard clinical tests, only 25% of the children had adequate binocular sensory fusion prior to vision therapy and 9% had adequate binocular fusional vergence. Post-training evaluation showed 96% had achieved appropriate sensory fusion findings and 75% demonstrated adequate fusional vergence ranges.

Wittenberg et al (210), along with Saladin and Rick (211), used slightly different techniques and demonstrated that stereopsis thresholds could be improved in normal subjects. In Dalziel's (212) study there was a statistically significant improvement in stereopsis after vision therapy.

[Strabismus]

Another category of binocular vision disorders is strabismus. Strabismus may be described as a misalignment of the eyes (referred to as crossed-eyes, eye turn, weak eye muscle, etc.). Many forms and variations of strabismus exist, depending upon direction and amount of the eye turn, the number of affected nerves or muscles, and the degree to which it is associated with reduced vision. The clinical characteristics and diagnostic criteria have been described in detail (212-215).

Numerous comprehensive reviews and studies relating to the success of vision therapy for strabismus exist. Flom (216) reviewed studies and used detailed multifactorial analysis. This revealed an overall functional cure rate for strabismics receiving vision therapy of 50%, with esotropia less responsive than exotropia. Ludlam (217) evaluated a sample of 149 unselected strabismics who received vision therapy and determined a 73% overall success rate utilizing the rigorous criteria established by Flom.

In a longitudinal follow-up study of this population, Ludlam and Kleinman (218) found 89% of these patients had retained their functional cure (binocular vision present). The long-term overall success rate of vision therapy was calculated at 65%. If one adopts a less stringent definition of "success, " such as the cosmetic criterion of "straight-looking eyes" employed in some less precise studies, the success rate increases to 96% of the re-analyzed population, or a 71% long- term success rate.

Flax and Duckman, (219) in their literature review of treatment for strabismus, found strong support for the efficacy of vision therapy for strabismus. They gathered data from numerous studies, each of which met rigorous criteria for success, and reported an overall success rate of 86%.

In a controlled study of 100 cases (220) Gillan reported that 76% of strabismic patients attained a cosmetic cure with orthoptics. None of those in the control group, treated with glasses alone, showed a spontaneous cure.

In a series of controlled studies conducted by Guibor (221-223), 50% of the experimental group achieved alignment of the eyes with glasses and vision therapy (orthoptics) as compared with only 12.5% of the control group who received glasses without vision therapy.

More recently, Ziegler et al (224) conducted a literature review of the efficacy of vision therapy for strabismus. An important contribution is their comparative analysis of published papers using the functional cure criteria defined by Flom. They noted the study conducted by Etting (225) in which he reported a 65% overall success rate in patients with constant strabismus (57% of esotropes and 82% of exotropes), 89% success rate with intermittent strabismus (100% of esotropes and 85% of exotropes), and a 91% success rate when retinal correspondence was normal.

In a study designed to investigate the effectiveness of vision therapy utilizing computer generated stereo graphics for subjects with strabismus, Kertesz and Kertesz (226) reported a 74% success rate in 57 strabismics. They combined traditional vision therapy techniques with computer generated stimuli as successfully applied by CooperO7 to the remediation of non-strabismic binocular vision anomalies. The functional cures obtained persisted on long-term follow-up visits for a period of up to 5 years.

Sanfilippo and Clahane (227) designed a prospective study of the results of orthoptic therapy for divergent strabismus (exotropia). Of the patients who completed the study, 64.5% attained a functional cure upon completion, and 51.7% retained this status on an average follow-up interval of 5 years and 4 months.

In two studies on the effectiveness of orthoptics (vision therapy) for intermittent and constant exotropes, Altizer (228) and Chryssanthou (229) found the majority of their patients had significant improvement in clinical findings as well as relief of symptoms.

Goldrich (230) reviewed records of patients completing a vision therapy program for exotropia of the divergence excess type. Of the patients reviewed, 71.4% attained a functional cure following approximately 5 months of standardized sequential therapy procedures used in-office as well as at home.

Several studies have applied biofeedback in vision therapy to assist in training patients to align their eyes (231-236). The use of biofeedback to enhance traditional vision therapy, provide reinforcement, and increase motivation was supported in these studies.

Strabismic patients exhibiting esotropia with anomalous correspondence tend to be the most difficult to successfully treat. The use of more aggressive and sophisticated techniques for vision therapy has been reported with a better success rate for anomalous correspondence and esotropia than earlier studies (237,238). In general, the treatment period tends to be longer for anomalous correspondence and esotropia than other types of strabismus.

Summary and conclusion

Vision is not simply the ability to read a certain size letter at a distance of 20 feet. Vision is a complex and adaptable information gathering and processing system which collects, groups, analyzes, accumulates, equates, and remembers information.

In this review, some of the essential components of the visual system and their disorders which can be physiologically and clinically identified. i.e., the oculomotor, the accommodative, and the fusional vergence systems have been discussed. Any dysfunctions in these systems, can lessen the quality and quantity of the initial input of information into the visual system.

Deficiencies in one or more of these visual subsystems have been shown to result in symptoms, such as blurred or uncomfortable vision or headaches, or behavioral signs such as rubbing of the eyes, eyes turning inward or outward, reduced job efficiency or reading performance, or simply the avoidance of near point tasks. In addition, these signs/symptoms may contribute to reducing a person's attention and interest in near tasks. The goal of vision therapy is to eliminate visual problems, thereby reducing the frequency and severity of the patient's signs and symptoms. Vision therapy should only be expected to be of clinical benefit to patients who have detectable visual deficiencies.

In response to the question, "How effective is vision therapy in remediating visual deficiencies?," it is evident from the research presented that **there is sufficient scientific support for the efficacy of vision therapy in modifying and improving oculomotor, accommodative, and binocular system disorders, as**

measured by standardized clinical and laboratory testing methods, in the majority of patients of all ages for whom it is properly undertaken and employed.

The American Optometric Association reaffirms its long-standing position that vision therapy is an effective therapeutic modality in the treatment of many physiological and information processing dysfunctions of the vision system. It continues to support quality optometric care, education, and research and will cooperate with all professions dedicated to providing the highest quality of life in which vision plays such an important role (1).

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