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The optometric control of myopia

Lance G. Anderson
Pacific University

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Abstract

A doctoral dissertation reviewing the current literature concerning the classification, etiology, and treatment of myopia. Five etiological theories are discussed, they include; genetic theory, normal biological variation theory, conditions of use theory, holistic theory, and deprivational theory. Treatment options were classified as being structural or functional in theory. Structural treatment options reviewed include; concave lens prescription, medical treatment, orthokeratology, and refractive surgery. Functional treatment options reviewed include; nearpoint lens prescription, vision therapy, holistic therapy, and biofeedback & visual acuity training. An integrative I holistic treatment model drawing from various treatment theories was developed as a means to better control myopia through the use of all treatment options available to the optometrist. The dissertation concludes that the optometric profession should look beyond the one dimensional treatment strategy of prescribing concave compensatory lenses when treating myopia. More emphasis needs to be given to preventative vision care, and control of myopic progression. Further clinical research investigating the efficacy of such a treatment plan is needed.

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THE OPTOMETRIC CONTROL

OF

MYOPIA

By

Lance G. Anderson

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Advised by

Dr. Bradley Coffey

ABOUT THE AUTHOR

Lance G. Anderson calls Grafton, North Dakota his hometown. He graduated from Grafton High School in 1982. Lance studied for two years at Lake Region Community College in Devils Lake, North Dakota before going on to Northern Montana College in Havre, Montana where he graduated with a Bachelors degree in broadfield science education. He was accepted for admission into optometry school at Pacific University in Forest Grove, Oregon during the fall of 1987.

While attending Pacific, Lance developed a deep interest in behavioral optometry. He was accepted during his fourth year of school to participate in an eight week vision therapy internship at the State University of New York. Lance will receive his doctorate of optometry degree on May 19, 1991. His future plans include entering private practice in the near future, while continuing to pursue various optometric writing endeavors.

DEDICATION:

This paper is dedicated to those students who
possess an open mind and a willingness to
look beyond the structured curriculum of an
optometric education for the answers which
will shape the future of our profession.

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ABSTRACT:

A doctoral dissertation reviewing the current literature concerning the classification, etiology, and treatment of myopia. Five etiological theories are discussed, they include; genetic theory, normal biological variation theory, conditions of use theory, holistic theory, and deprivational theory. Treatment options were classified as being structural or functional in theory. Structural treatment options reviewed include; concave lens prescription, medical treatment, orthokeratology, and refractive surgery. Functional treatment options reviewed include; nearpoint lens prescription, vision therapy, holistic therapy, and biofeedback & visual acuity training. An integrative / holistic treatment model drawing from various treatment theories was developed as a means to better control myopia through the use of all treatment options available to the optometrist. The dissertation concludes that the optometric profession should look beyond the one dimensional treatment strategy of prescribing concave compensatory lenses when treating myopia. More emphasis needs to be given to preventative vision care, and control of myopic progression. Further clinical research investigating the efficacy of such a treatment plan is needed.

FOREWORD

Interest in the causes and treatment of myopia has reached an unprecedented level during the last decade. The frequently-maligned optometric perspectives that myopia is influenced by environmental factors such as prolonged near work with focused concentration, and that the onset and progression of myopia can be predicted by careful visual evaluation, are gaining widespread acceptance among vision scientists. The discovery in the late 1970's that myopia can be produced in laboratory animals by various forms of visual deprivation was the first trickle in what has become a flood of research activity that seeks to define the parameters which regulate induced myopia and, more importantly, the variables which affect the process of recovery from experimentally-induced myopia, emmetropization. This ongoing work has led to a consensus of opinion in the scientific world that myopia is indeed influenced by environmental interactions, and that the nature of these influences may be quite subtle or quite profound.

Coupled with this work on animal models of myopia has come the first longitudinal data on humans from which can be derived several risk factors for the development of myopia. These risk factors indicate the presence of a genetic factor for myopia, and also suggest that certain preventative measures instituted with very young children may minimize the chance of developing myopia.

In light of these encouraging developments from the research labs, the topic of this thesis is especially timely. Dr Anderson has successfully endeavored to provide the clinician with a comprehensive overview of what we know about causes of myopia and the various treatment strategies that have been historically applied in myopia. He suggests that most clinicians tend to be rather myopic in their management of myopia, and that what is needed is a broader, more fully integrated treatment approach. After presenting the various mechanisms and processes which have been implicated in the development and progression of myopia, he develops an integrated treatment approach which is harmonious with our current state of knowledge, and which honors time-tested optometric clinical strategies.

This thesis is unique in that it represents the outcome of a disciplined study of both published literature and clinical wisdom. The sort of thinking that guided the development of this work represents the best of modern optometry: an awareness of current advances in vision science coupled with, and interpreted through, a mature clinical science. Dr. Anderson is to be commended for his contribution to our professional knowledge, and for his commitment to the search for more effective means to control myopia.

Bradley Coffey, O.D.
May, 1991

PART ONE

INTRODUCTION

Chapter 1.
INTRODUCTION

"When a tradition once becomes established by the hallmark of acknowledged authority, it takes more than cold facts to uproot it from men's minds - it takes time."
W. Nicholson, 1919

Myopia is a visual condition in which only nearby objects appear in focus. A number of mechanisms attempting to explain the mechanism by which myopia occurs have been proposed within our profession. Although the literature regarding this refractive condition is quite extensive, little is actually known concerning its etiology. A number of etiological theories exist, all of which have support from certain factions of the optometric profession. There are a number of treatment options available as well, many of which are dependant on the validity of a certain etiology theory. Because the topic is fairly controversial and because the majority of practitioners feel comfortable with one etiology theory and one treatment strategy only, little has been done to investigate the combination of various treatment strategies to develop an overall myopia treatment program.

It is the purpose of this paper to review the available literature concerning the various etiological theories and treatment options available to our profession today. Drawing from this review of the literature, an integrative model of treatment will be developed which emphasizes prevention, control, and the reduction of myopia. Because non-conventional treatment options are included, some of the information contained within these pages will be difficult for some to absorb. It is those readers who approach this paper, and the topic of myopia, with an open mind who will be inspired to search for answers to the many questions which remain concerning the multi-faceted topic of myopia.

Chapter 2.
CLASSIFICATION

Myopia has been classified in a number of different ways. Methods include classification by cause and effect as proposed by Curtin[1]. Borish[2] cites classification systems based on the dioptric amount of the refractive condition and on the origin of the refractive condition. Birnbaum proposed a classification system by stage of progression[3]. For an extensive review of the history of classification systems for myopia, see Grosvenor[4]

Curtin[1] in his book entitled, *The Myopias, Basic Science and Clinical Management,* introduced a system of classification based on the source, degree of myopia, and time of onset. His three catagories of myopia include:

1) Physiologic (low, simple) Myopia - According to Curtin, "in physiologic myopia each component of refraction lies upon its normal distribution curve. The postnatal development of these eyes is normal; they are rendered myopic because of a correlation failure between the total refractive power (corneal and lens) and a normal axial diameter. The heredity of this myopia is considered multifactorial and, in addition to the hereditary pattern of each of the refractive components, there is the added possibility of a hereditable correlation defect." Curtin states that myopia of 3 D or less is "to the greatest extent physiologic".

2) Intermediate (medium, moderate) Myopia - This type of myopia is seen by Curtin as sharing characteristics of physiologic and pathological myopia, and is due to an expansion of the posterior segment of the globe that is greater than that of normal ocular growth. Typically intermediate myopia is considered to be between 3 and 5 D.

3) Pathological Myopia - Curtin describes this class of myopia as an ocular disease in which a number of serious complications are associated with elongation of the eye. Such complications include scleral and pigment crescents, tesselation, white without pressure, and various peripheral retinal degenerations such as lattice, and paving stone.

Borish[2] proposes a classification system based solely on the diopric amount of the refractive condition. The classifications are: very low (up to 1.00 D), low (1.00 D to 3.00 D), medium (3.00 to 6.00 D), high (6.00 D to 10.00 D), and very high (above 10.00 D). Also cited by Borish[2] is a classification system by Sorsby which classifies myopia by origin. The two divisions are correlative (up to 4.00 D) and component (over 4.00 D).

Birnbaum[3] identifies three classifications of non-pathological myopia according to the stage of progression, rather than the amount of myopia. The three stages are incipient myopia, active progressive myopia, and stable myopia:

Incipient myopia is an early stage of myopia which is often associated with asthenopic symptoms, distance blur after nearwork, and avoidance of nearpoint tasks due to discomfort. These symptoms are generally caused by decreased flexibility of accommodation and nearpoint esophoria due to the excessive effort involved in accommodating. According to Birnbaum, this stage of myopia will be responsive to the use of plus lens power at nearpoint to reduce accommodative demand, appropriate visual hygiene to reduce stress on the accommodative system, and vision training to improve accommodative efficiency.

The active progressive stage of myopia is not commonly associated with asthenopic symptoms, but is associated with esophoria at near with signs of accommodative problems and indications for plus lens power at near. According to Birnbaum, this stage of myopia is difficult to reduce.

Stable myopia is the final stage in which myopic progression has stopped and myopia becomes stable. In the stable stage, signs of accommodative problems such as nearpoint esophoria and low PRA, are no longer present. A change in lifestyle which involves an increased amount of nearpoint visual demands may cause a reversion back to the progressive stage. According to Birnbaum "vision training to reduce or eliminate the myopia is generally quite unsuccessful, even in highly motivated patients."

PART TWO

ETIOLOGIES

There have been numerous efforts throughout the years to identify the etiology of myopia. Through these efforts a number of theories have been introduced and accepted by the optometric and ophthalmologic communities. A comprehensive review of many of these studies may be found in Borish.[2] For the purpose of this paper five theories of myopia etiology will be included.

1. The Genetic Theory
2. The Normal Biological Variation Theory
3. The Conditions of Use Theory
4. The Holistic Theory
5. The Deprivational Theory

Chapter 3.
GENETIC THEORY

One of the questions which immediately arises when discussing the etiology of myopia is whether it is a hereditary dysfunction which is passed along from generation to generation, or whether it is acquired through certain environmental influences such as sustained nearpoint work.

A recent paper by Goss et al.[5] reviewed genetic factors in myopia. When examining various pedigree studies to search for the mode of inheritance for low myopia[6,7,2,8] it is evident that there is a lack of consistency between the results and the proposed mode of inheritance. Goss et al. attribute this inconsistency to: inadequate study design arising from problems such as small family size; inconsistent use of the terms *low*, *moderate*, and *high* myopia; inclusion of children who are still changing in refractive status; selection bias; and lack of recognition that there may be several types of low myopia with different forms of inheritance. Goss et al. state that the most probable explanation is that the etiology of low myopia is multifactorial, and that environmental influences make a significant contribution to low myopia.

After examining pedigree studies to find a mode of inheritance for high myopia[6,2,9] Goss et al. conclude that modes of inheritance seem to be more clearly established in high myopia than in low myopia. At this point, there is no agreement on what exactly the mode of inheritance may be. Studies have concluded that it is autosomal recessive[6]; a variation between recessive, dominant, and sex-linked[10]; a variation between recessive and dominant[11]; and sex-linked[9]. Also, the same potential study design problems exist when studying the inheritance mode of high myopia.

Many studies concerning the role of heredity in myopia have compared amounts of myopia for twins, siblings, and unrelated individuals. A number of investigators have found a high correlation in the refractive condition of monozygotic twins[12,13] indicating a genetic mode of inheritence. Sorsby et al.[14] concluded that all components of refraction are genetically determined. Goss et al. point out that a major flaw in these heritability studies is the extent to which the environment of parents and offspring is similar. Several studies in which this point is emphasized are reviewed by Goss et al.; one such study is by Ashton.[15] While studying the correlation of refractive condition between parents and off-spring in Hawaii, he found the prevalences of myopia in the off-spring to be 10-11% for families in which neither parent was myopic; 16-25% for families in which one of the parents was myopic; and 33-46% for families in which both parents were myopic. Ashton did not find evidence of a single dominant or recessive major gene contributing to these cases of myopia, and proposed that similarity in refraction among siblings was due mainly to a "non-genetic familial component" which Goss et al. interpreted to be the common familial environment.

Advocates of the genetic etiology theory point to studies which show differences in myopia prevalence among different ethnic groups[2] as being evidence of a genetic etiology. The fact that certain ethnic groups, such as Asians and Jews, have a greater prevalence of myopia[16,17] is seen as evidence for the genetic etiology theory. Many ethnicity studies are used to prove the environmental theory as well. An example is the study conducted by Young et al.[18] who reported a large increase in the amount of myopia among a relatively non-myopic Eskimo population following the introduction of compulsory education.

Goss et al. state that "the genetic input to myopia development is probably derived from more than one gene, and that it is likely that myopia development results from a complex interplay of genetics and environment." Bastien[19] theorized that "one is born with certain genetic and temperamental predispositions to myopia. The propensity to integrate, to manipulate thoughts and ideas as well as real objects in a move towards self is most likely inborn and inherited. Its visual consequences are, however, under optometric control." Young[20] states that "it is unlikely that refractive error is determined primarily by hereditary factors."

Chapter 4.
NORMAL BIOLOGICAL VARIATION THEORY

This theory contends that a person's refractive condition is due to normal biological variations found in the dioptric components of the visual system. The components which are most often considered in these types of studies are: (1) the cornea, (2) axial length, and (3) crystalline lens power.

Most studies of refractive condition have found that the axial length exerts the greatest effect, the cornea exerts a moderate effect, and the lens the least effect.[2] Sorsby[14] plotted the refractive conditions of a large population and found that when displayed on a graph the curve is bell shaped, indicating a normal distribution. The peak of this bell curve was found not at emmetropia, but rather at 1.00 D of hyperopia. Emmetropia appeared to be in the range of 0 to +2.00 D. An equal number of myopes fell between 0 and -4.00 D, as did hyperopes between +2.00 and +6.00 D. When a comparison was made between the curve of an infant population and that of an adult population, the incidence of myopia was found to be greater among the adults.

Sorsby et. al. postulated a biological concept of refractive error. A detailed review of this concept can be found in Borish.[2] The concept proposed two types of ametropia:

1) <u>Correlational Ametropia</u>

All components of the eye are variable and fall upon a curve of distribution with most of them falling within normal limits. When an ametropia exists it is due to errors in the correlation of these components. The emmetropic eye shows a high correlation of its refractive components.

2) <u>Component Ametropia</u>

Ametropias which are component in nature are usually high in extent and at the extremes of the distribution curve. This type of ametropia is considered to be due to an abnormality of one of the components, usually the axial length.

Sorsby et al.[14] stated that when the individual components of refraction were considered, axial length was the major contributing factor in myopia. Adams[21] cited his own case of myopia as being clearly related to an increase in the axial length of the eye. Wallman et al.[22] have induced axial length elongation and an associated myopic refractive condition in chickens via visual deprivation which suggests that axial elongation may be a response to image degradation. It is widely accepted that cases of significant myopia are associated with an increased axial length, but the question remains as to why the axial length is longer in some eyes compared to others. The answer may be the sclera.

Bell[23] states that "the usual situation in significant myopia is a sclera that is thinner, has reduced rigidity, and may expand at a faster rate than the retina or choroid." The sclera is the most rigid tunic of the eye, and is largely responsible for the overall shape of the eye. Evidence that the stretching of the sclera may play a role in the axial length of the eye is seen in the scleral or choroidal crescents commonly seen in cases of significant myopia, and also the fact that high myopia is associated with a thin posterior pole of the sclera.[24] Furthur evidence of a stretching of the eye is the retinal stretch lesions commonly seen in cases of high myopia. It has been proposed that scleral thickness is an anatomical variable that may be a genetic trait.[24] Another theory, by Watson & Hazleman[25], is that naturally occurring corticosteroids, (such as growth hormone, thyroxine, androgens, etc.) when present in excess interfere with production of hyaluronic acid and collagen. Bell[24] states that it is possible that during the adolescent years, due to an increase in these growth hormones, the sclera often does not develop to its full thickness due to hormonal suppression of collagen formation. Furthur evidence related to myopic changes in choroid and sclera will be discussed in the section, "The Visual / Cortical Deprivation Theory."

Chapter 5.
CONDITIONS OF USE THEORY

Myopia has long been associated with sustained nearpoint visual activities. Cohn, in 1867, was one of the first to relate myopia with near work. He attributed myopia to repetitive overuse of accommodation. Since then many papers have been published which provide evidence for the conditions of use theory.

Greene[26] reported that submariners who were confined to a restricted near environment for prolonged periods of time developed myopia. There are studies which clearly show an increase in the prevalence of myopia among graduate students[27,28] and military cadets[29], all of whom are exposed to long periods of near work while studying. Many studies show that myopes tend to read more[30,31,32] and achieve at higher levels academically.[33,34] Young[35] showed in his study of an Eskimo community a large increase in the incidence of myopia with the introduction of compulsary formal education. A question that is yet to be answered concerning the conditions of use theory of myopia is: What factor or factors cause this development of myopia in persons exposed to near work conditions?

Skeffington[36] proposed a nearpoint theory in the 1930's in which he stated that the "socially compulsive, near-centered tasks" of modern society provoke a stress reaction which causes a mechanism for a drive of convergence to localize in front of accommodation. Skeffington termed these biologically unacceptable nearpoint tasks as stressors, because they require sustained concentration, immobilization for extended periods of time, and information processing through symbols in a two dimensional setting. If a person is exposed to these stressors for extended periods of time, adaptations are said to occur.

The following are examples of adaptations which may occur in response to the stressor stimulus[37]; (1) avoidance of the nearpoint task, (2) the development of myopia, or (3) the development of a high amount of exophoria to act as a buffer for the resultant mismatch between the accommodative and convergence systems. This adaptation may present clinically as a convergence insufficiency, divergence excess, or an exotropia. Within this nearpoint theory by Skeffington, myopia is not viewed as a primary visual problem but rather as an adaptation which arises due to the localization of convergence closer than accommodation.

Myopia is viewed as an effective adaptation to nearpoint stress which permits efficient, comfortable nearpoint function at the expense of distance acuity. This adaptation occurs through a number of steps[38,39]. The initial stress occurs due to the sustained effort involved in the nearpoint task. An increase in sympathetic innervation occurs causing a shift of accommodation toward the farpoint. The system attempts to adapt to this stress by increasing parasympathetic innervation to bring accommodation back to the plane of regard. This stimulation of accommodation brings about an increased amount of accommodative convergence, which in turn results in overconvergence at the nearpoint. A new relationship then exists between accommodation and convergence in order to attain clear single binocular vision . The new relationship involves using greater effort for accommodation than for convergence. When the person shifts attention to the far point, the increased accommodative effort is not appropriate and a stress situation, due to blur, occurs at far.

Accommodation has long been the targeted culprit in cases of nearpoint induced visual dysfunctions. Francis Young[40] has done extensive research with primates, enclosing them in a restricted nearpoint environment which is ergonomically similar to the nearpoint demands placed on children at school. Young's findings showed that primates raised in this restricted nearpoint environment showed a 75% greater incidence of myopia than those primates raised in normal laboratory cages. It was also shown that those primates raised in the wild develop far less myopia than those raised in the cages. When these experiments were conducted with the primates cyclopleged, the primates did not develop myopia, suggesting an accommodative etiology induced by the nearpoint environment. Young[41] also postulated another element while studying the accommodative response of the primates to a nearpoint environment. Young discovered an increased intraocular pressure in the vitreous chamber of up to 6mmHg during periods of accommodative response. This finding correlates with the Coleman theory of accommodation[24], which states that accommodation causes an increased posterior chamber pressure, which is offset by scleral elastic resistance. This perspective has implications on the increased axial length which is associated with cases of significant myopia.

Bell[23] has proposed that the increase in the accommodative demand at near, may be one of the factors which produces stress actions on the sclera causing an increase in axial length and therefore myopia. Bell theorized that the force of ciliary contraction stretching the ocular coats as a result of sustained accommodation, and intermittent rises in vitreous pressure, also from sustained accommodation, are those most capable of altering scleral structure. Bell believes that "the usual situation in significant myopia is a sclera that is thinner, has reduced rigidity, and may expand at a faster rate than the retina or choroid." Bell's theory on accommodation and myopia correspond with the Coleman theory of accommodation which places an emphasis on the role of the sclera and the increase in pressure of the posterior chamber during sustained accommodation. The Coleman theory states that with a genetic or environmental defect in scleral collagen, accommodation can exert enough stress on the sclera to cause stretching and an increase in length of the posterior chamber.

Kruger[42] has shown a relationship between accommodation and increased cognitive demand. A change in task from simply reading numbers to adding numbers resulted in a small increase in measurable accommodation. Bastien[19] has theorized that myopia is related to cognitive processing as well. According to Bastien, "a near task that does not call on cerebrotonic mobilization does not have the same impact on posture and function that a near deciphering task has."

The relationship between accommodation and the nervous system was investigated by Gilmartin[43]. In his review of the role of sympathetic innervation of the ciliary muscle in ocular accommodation, Gilmartin has shown that the literature supports the notion that the ciliary muscle is indeed dually innervated by the parasympathetic and the sympathetic nervous systems. He has also shown that the literature provides evidence that "sympathetic innervation of the ciliary muscle produces an inhibition of accommodation that is small, slow, and a function of the concurrent level of parasympathetic activity." His review points out that it is not likely that the sympathetic system plays a significant role in the rapid near-to-far accommodation that is measured clinically, but rather the sympathetic input acts to "minimize the risk of accommodative hysteresis inducing manifest myopia following near-vision tasks."

If one were to consider the focusing mechanism of the eye in terms of fast and slow accommodative processes, it is easier to understand Gilmartin's theory of the roles of the sympathetic and parasympathetic systems. The rapid near-to-far focusing that is required of humans in our near-centered society is innervated primarily by the parasympathetic system. If someone does work at near for long periods of time, a sympathetically induced shift of the tonic accommodative posture occurs in the direction of effort.[44] Under stress, the sympathetic system moves the accommodative posture toward farpoint, causing an increase in the level of parasympathetic innervation and effort needed to maintain a clear focus at the plane of regard.

Owens & Wolf[45] have proposed that the inward shift of tonic accommodation serves to relieve the effort required by sustained nearpoint visual tasks It is possible that a sympathetically induced inward shift of the accommodative resting level results in a new "baseline setting" for the visual system which is nearer in space than what is optimally desired. This change in the tonus level of the visual system may occur in order to compensate for the parasympathetically induced levels of increased accommodation and convergence associated with the nearpoint task. The movement of the accommodative mechanism toward near while engaged in near-centered activities would result in an increased hysteresis effect and possibly pseudomyopia, which is thought by many to be a beginning stage of functional myopia.

Chapter 6.
HOLISTIC THEORY

Practitioners often associate the term 'holistic' with non-medical or at best pseudo-medical modes of treatment. For the sake of this paper the term is used to describe factors not pertaining to the eyeball, but rather to the human as a complete system. In order for the body to function as a whole, the visual system must be efficient and, likewise, in order for the visual system to function properly the body must be healthy and efficient. Some factors which can cause a decrease in human function include; physiological stress, poor nutrition, and psychological / emotional factors. There is a body of literature which associates these factors with decreased visual performance, and specifically with myopia.

The first person to go beyond the eye itself as the cause for myopia was a New York ophthalmologist, William H. Bates. Bates became quite disturbed by the fact that many patients would come to his office for yearly examinations and would often need stronger and stronger lens prescriptions in order to see clearly. Bates began to experiment with different modes of treatment beside the use of concave lenses, and found some of his methods to be successful. Bates discovered by performing retinoscopy on thousands of subjects that the refractive condition is not static but rather changes depending upon the emotional state of the individual. According to Bates[46], vision problems are due to temporary and emotional attitudes which are a part of our modern culture. Anxiety, fear, and even being placed in a strange environment, according to Bates, will result in a myopic change in the refractive condition. Bates, then, saw myopia as being related not just to the eyes but to the mind as well. According to Bates, when the mind is at rest, nothing can tire the eyes, and when the mind is under a strain nothing can rest them. An example of this is the observation by many that the eyes seem to tire more quickly while reading something which is difficult to comprehend as compared to reading something that is easily understood and enjoyable. Bates claimed that vision could be improved, and that the secret is relaxation of the mind and eye.

Bates was ostracized by the medical community for his radical views on vision, yet he had a number of followers. People were getting results using the Bates method of vision improvement. Today there are numerous books available dealing with the subject of vision improvement, but because many of them are written by non-medical authors, the scientific community chooses, for the most part, to ignore their content. When examining this body of literature one must remember that most of it is based on the works of a medical doctor, William H. Bates. The fact that there are so many books available today on this subject is evidence in itself that there may be a piece of the myopia puzzle which can be found in Bates' work.

Along with the non-optometric sources there is a body of literature written by optometrists, many of whom also credit Bates as their source of inspiration. These eye care professionals are going beyond the visual system and looking at such factors as the mind and emotions as well as the response of the body and the visual system to such factors as stress and nutrition. To appreciate this holistic etiology theory, one must have an understanding of the components from which it is comprised.

1. PHYSIOLOGICAL STRESS

Hans Selye, M.D., defines stress as the "nonspecific response of the body to any demand made upon it."[47] This response of the body may be triggered by a multitude of interactions with our environment, which vary among different individuals. It may be induced through physical changes such as general movement, exercise, temperature shifts, humidity changes, noise, trauma, disease, or diet. It can be induced by social changes such as marraige, divorce, death, economic changes, and all kinds of personal relationships. It can also be induced psychologically through one's attitudes, desires, and emotions. This lack of a specific cause for the stress response to occur is termed by Selye as non-specificity, meaning that although the stress response has a particular form, it has no specific cause.

The form (or mechanics) of the stress response according to Selye is seen as a three part process termed the General Adaptation Syndrome (GAS) and/or the Local Adaptation Syndrome (LAS). The GAS affects large portions of the body whereas the LAS represents the action of specific stressors which have a localized effect on a specific part(s) of the body. Both the GAS and LAS consist of three stages: 1) the alarm reaction, 2) the stage of resistance, and 3) the stage of exhaustion.

The alarm reaction is the response of the body to the stressor. It is characterized by sympathetic activation along with parasympathetic inhibition, a discharge of adrenalin and, if chronic, a loss of body weight and a lowering of resistance. It is during this stage of adaptation that the heart rate increases, breathing becomes fast and shallow, and the extremities become cooler as blood flow is directed away from the skin and toward the brain and skeletal musculature to prepare for the response to the stressor. Selye points out that "no living organism can be maintained continuously in a state of alarm."

During the stage of resistance the body begins to adapt by increasing it's amount of resistance. This stage is characterized by an accumulation of adrenalin rather than a discharge, a return of body weight to normal, and a rise of the body's resistance to above normal levels. The fact that adaptation requires energy is the premise for the third stage, which is the stage of exhaustion. If during the stage of resistance too much energy is used by the body to resist the stressor, exhaustion will be the result.

Selye hypothesized two types of adaptation energy. The first type being superficial adaptation energy which is always available and accessible. This type of energy can easily be restored through rest or a vacation. The second type, he termed deep adaptation energy. This energy is stored in the body as a reserve and can be accessed, but only with some amount of difficulty.

Walter Cannon[48] presented the view that the body's response to stress was mediated mainly through the autonomic nervous system. He described the response as being a fight-or-flight response to generate action against the stressor. According to Cannon, this response consists of an activation of the sympathetic system initially, followed by activation of the parasympathetic system to restore equilibrium to the organism. Pelletier[49] describes the overall characteristics of excess sympathetic activation as being: dilated pupils; tight throat; a tense neck and upper back, with the shoulders elevated; shallow respiration; accelerated heart rate; cool, perspiring hands; a locked diaphragm; a rigid pelvis with the genitals numb and the anus tight; flexor muscles in the legs contracted and extensors inhibited. According to Pelletier, these reactions are a preparation by the organism to engage in fight-or-flight activity, and that each of these symptoms is a clue to the individual that he or she is under stress.

Kraskin[50] states that the vast majority of vision conditions are those labelled as being stress-induced visual problems, which emerge in increasing incidence as the school-age years advance. A major characteristic of myopia is the fact that a vast majority of cases develop and increase during the school years as well. Kraskin does not term myopia as a nearpoint visual problem, and claims that the problem is not in the eyes. Rather, it is more appropriate to say that the near-centered demands may be the stressor agent which produces persistent stress, requiring adaptation. The adaptation is adverse in its effect on the body, since structural alteration is required to permit maintanence of function with the least expenditure of energy. Kraskin[51] states that myopia is seen clinically as either a primary adaptation or as a secondary response. Primary myopia is that which is seen early in life and is the initial response to the imposed stress. Secondary myopia, such as that which first occurs during early adulthood, occurs as a secondary response to an additional stress. Kraskin furthur states that when relating myopia to the physiological stress theory, its development can be viewed as the adaptation of *fight*, while reduced visual efficiency or avoidance may be viewed as the adaptation of *flight*.

Bastien[19] proposes that myopia is much more than an elongated eyeball. He states "myopia is the effect of an evolutionary process resulting from the maintained response of a predisposed organism to the near centered exigencies of cipher / deciphering tasks imposed by learning, also by prolonged reading sessions." Bastien states that "biologically, myopia should be considered a successful adaptation of the organism to its surroundings. Also, it should be considered as a specialized morphological response of the organ (and the organism) to the demands of the near-centered tasks of learning for the sake of efficiency. Bastien furthur states that "this incessant cerebral manipulation of ideas is done by the total organism. It is not done by the eyes alone or by the brain alone. It is observable and measurable as variations in space manipulation, as subtle postural moves, and as an inhibition of muscle activity."

Birnbaum has expounded on Skeffington's model of nearpoint stress, in which he relates the effects of physiological stress to the visual stress of the nearpoint task. In one such paper [52] Birnbaum proposed a physiological model for nearpoint stress based on arousal of the autonomic nervous system and the reaction of the body to physiological stress. Birnbaum states that "reading imposes demands for vigilant attention and mental effort which generate sympathetic arousal and a consequent shift of accommodation toward far." His theory is that during reading, increased parasympathetic innervation is needed to overcome the sympathetic "fight or flight" innervation which causes a shift of accommodation toward far. The increase in accommodative effort produced by the heightened parasympathetic innervation causes an increase in accommodative convergence and is the source of the drive for convergence to localize in front of accommodation as postulated by Skeffington.

Forrest[53] contends that stress comes not from the task, but "from one's approach to the task and the often sub-concious interpretations and judgements that act as a pre-set." According to Forrest, this affects how one functions by inducing muscular rigidity that can persist even when the task is completed. Furthermore the negative effects of restraint, tension, immobilization, and sensory underload & overload stem from the individual's inability to flow with events rather than from the specific stress agents alone. By using what Forrest terms as a psycho-behavioral approach to myopia, the clinician probes into the psychological / emotional aspects of the patient's life. This approach may be useful in deciding the course of action to take with each patient, on an individual basis. According to Forrest the principle factors in the stress response of the patient are those mental attitudes that are generated by deeply hidden feelings of inadequacy, vulnerability, helplessness, and the fear of change. These and other psychological characteristics are mentioned extensiveley in the literature relating myopia to psychological and emotional factors.

2. PSYCHOLOGICAL & EMOTIONAL FACTORS

There is evidence that psychological / emotional factors may be of some significance in the etiology of myopia. A consistent list of personality traits has been associated with myopia. Kelley[54] describes the myope as being inward, self-oriented, shy, "good" in school, often "off" in daydreams, comfortable with eyes closed, and tending to subvocalize and retreat from visual perception inward. Goodrich[55] states that the myope often feels isolated, feels incompetent yet continues to compete, and feels a need to demonstrate self worth. Mental attributes of myopes according to Goodrich are: they think more than they imagine, they fantasize more than they create, they are unspontaneous in humor, and they compare themselves to others unfavorably. Young[40] has stated that "myopia is related to behavior," and he claims it is possible to identify potential myopes and nonmyopes by observing their behavior and determining their values and goals. Bastien[19] and Bates[46], through clinical observations, have noted that the degree of myopia changes in relation with psychological conditions. Under stressful or fearful conditions a relative myopic condition will be measured, whereas a hyperopic measure may be seen under less stressful or pleasant conditions.

Gawron[56,57] has postulated a link between refractive condition, personality, and the autonomic nervous system. She has found that myopes tend to exhibit a dominance of the sympathetic system. Gelhorn[58] has concluded that "fear causes reactions predominately sympathetic, and feelings of hostility and anxiety are predominately parasympathetic discharges." These findings apparently correlate with the studies which have linked myopia with a feeling of fear and introversion.[59,60,61] Zeiger[62] states that "low and moderate myopes show the problems and attitudes myopes have, and the high myopes show the solutions that myopes have."

Forrest[53] has associated myopia with central processing or a prolonged central fixation time with an associated reduction of peripheral awareness. Goodrich relates these visual characteristics to the feeling of being walled in; not feeling as though you are connected to life's broader meaning; having eyes and a mind that tend to stick to things, repeatedly buzzing around the same topic. Kelley[54] described myopia as being an inward flow of energy, toward self. He based his work on that of Reich and Bates, and felt that the myope takes on a "coat of armor" to block the feeling of fear and the expression of fear. Reichian therapists have observed that myopes tend to hold tension in the chest, neck, and shoulders and are frozen in a flinching posture. These postural traits have been termed by Bastien as the "myopic posture."[63] Kraskin[51] states that concave ophthalmic lenses actually increase tonicity of the posturing muscles of the body. This increase will then result in a shifting of the center of gravity forward causing body alterations in the direction of a more myopic posture, and eventually causing more myopia to be measured in the visual system. It is the belief of Kelley that through methods such as Reichian therapy and various types of stress reduction therapies one can peel away the layers of myopic behavior, and possibly improve vision as well.

3. NUTRITIONAL FACTORS

Many investigators have taken an interest in the role of nutrition as it relates to myopia development. Price[64] observed in 1939 that myopia was less common in countries which maintained their traditional diets. He attributed the degenerative effects of myopia to the paucity of vitamins in cultures relying on commercially prepared foods. Reed[65] found an increase in the incidence and degree of myopia among World War II war prisoners, and attributed this to malnutrition. A strong case may also be made for stress in this case. Bowan[66] feels that nutritional imbalances are usually stress induced.

Lane[67] has done extensive research on the relationship of nutrition and myopia. He has suggested three related deficit-inducing diets associated with the development of myopia; (1) excess consumption of refined carbohydrates (sugar), (2) excess consumption of denatured flesh proteins, and (3) inadequate intake of dietary fiber and folate. Lane[67] reported that young myopes consumed more than triple the ratio of refined carbohydrates to total carbohydrates as compared to hyperopes, had a higher intake of flesh proteins, and ingested daily a mean of 5.58 grams of dietary fiber while young hyperopes, on the average, consumed 15.43 grams per day.

The sclera has been targeted as a bodily tissue which may be affected by nutrition. According to Robertson,[68] Vitamin C participates in the formation of collagen and increases the tensile strength of collagen fibrils. A deficiency of Vitamin C, therefore, could decrease the ability of the sclera to withstand the axial elongation which has been associated with myopia. Rotman[69] has noted that the scleral changes in myopia are very similar to the general connective tissue changes seen in scurvy. Bell[24] postulates that the high frequency of myopia in illiterate populations could be due to a deficiency of dietary vitamin C. This could lead to faulty connective tissue synthesis and a weakened sclera which is more vulnerable to stress.

Kappel[70] provides a list of physiological variables which may influence myopia: tissue strength and tone, corneal tissue clarity, nerve function, circulation, and stress. According to Kappel, all of these can be affected to some degree through a proper nutrition program. Kaplan[71] obtained favorable results when participants in a vision improvement study were asked to eliminate red meat, alcohol, sugar, processed foods, and dairy products. Kaplan feels that the ciliary muscle is sensitive to fluctuations in blood sugar levels, and that when these levels are disrupted, decreased visual acuity is a possible result.

Chapter 7.
DEPRIVATIONAL THEORY

Recently, investigators have demonstrated that visual deprivation and image degradation in animals during early postnatal development can produce a large amount of myopia. Studies have been conducted on various types of laboratory animals, mainly monkeys[72], kittens[73], and chickens[74].

Raviola and Wiesel[75] demonstrated that when lids are surgically fused in rhesus monkeys before eye growth is completed, a high degree of myopia develops, which is caused by an elongation of the eye globe. When the monkeys were raised in the dark, however, no significant increase in the degree of myopia was noted indicating that the deprivation of the incoming light is not the cause of the myopia development. They concluded in a later paper[72] that the axial elongation of the globe produced by form deprivation is caused by an alteration of the visual input, and is mediated by the nervous system.

Hendrickson and Rosenblum[73] investigated the effect of deprivation on the development of myopia in kittens. Image degradation was accomplished by performing radial keratotomy to induce a relative hypermetropia, and by instilling atropine monocularly on a daily basis. They reported that atropinization resulted in a shorter axial length than in those kittens which were not cyclopleged. From their findings, they concluded that ocular growth may be a self-regulating process guided by visual experience and dependant upon intact accommodative function.

Sivak and Seltner[76] induced extreme myopia in chicks with only a fourteen day deprivational period. The deprived eyes, when compared to the controls, showed a mean refractive condition of 11.3 D more measureable myopia, and were larger both axially and equatorially. The induced myopia appeared within 4 days after the deprivation was applied, and was totally reversible at least within the first 4 weeks of hatching. Sivak and Seltner reported that the induction of experimental myopia appeared to have no effect on the physical, total protein or optical properties of the lens. They stated that the lens does not seem to contribute to the overall large refractive condition observed, and appears to be relatively resistant to changes in the visual environment. In a recent letter to the editor[77], Sivak contends that accommodation plays a very small role, if any, in the development of myopia.

Schaeffel et. al.[78] applied defocusing concave and convex lenses to chicken eyes during early postnatal development. The application of these lenses resulted in consistent shifts in the noncycloplegic refractive condition. The shifts were always in the direction which compensated for the defocus provided by the lens. Another study of this type[79] was done with kittens which yielded similar results The axial length was found to be longer in eyes treated with concave lenses than in those treated with convex lenses. Schaeffel et. al. concluded that their results are consistant with the theory that the accommodative tonus is a factor in the eye growth due to its role in the tuning of the retinal plane to the image plane. They also found parallels between their findings and the "closed-loop" feedback system which includes the accommodative tonus as a parameter.

Investigators have found evidence that deprivation to certain regions of the retina can produce myopic changes in the refractive condition. In seperate studies Hodos et. al.[80] and Wallman et. al.[74] investigated the effects of frontal field deprivation vs. lateral field deprivation. Wallman et. al. found that animals whose vision was confined to the frontal visual field were extremely myopic (mean, -10 diopters), unlike the lateral-field animals (mean, +1.9 D), which did not differ significantly from the normal animals. They also found the axial length of the eyes of the frontal-field animals to be significantly greater than that of either the normals or the lateral-field animals. Hodos et. al. suggested from their results that degradation of lateral (axial) vision in chicks can produce an axial myopia. In a later study Wallman et. al. propose that restricting vision to only the frontal field may cause an increase in ocular accommodation, which in turn produces the myopia. They suggest the restriction to frontal vision might increase the amount of close visual activities that the chicks do, since chicks use the frontal visual field extensively for close (2-5 cm) visual inspection of objects prior to pecking, which is their principle means of tactile exploration. Alternatively, the extreme myopia produced with the use of occluders may be the result of increased accommodation provoked by a large empty visual field.[81]

Parallels have been drawn between these experimental myopia animal studies and human myopia development. Perhaps the most thought-provoking, is the theory proposed by Wallman et. al.[82] which suggests that the two conditions linked to myopia in humans and animals - large amounts of reading and deprivation of form vision - both cause myopia by visual deprivation. Wallman et. al. conclude that although the printed page may provide adequate stimulation for the foveal retina, it could provide an impoverished stimulus environment for other regions of the retina, resulting in myopia. Three factors were cited as possible evidence for this mechanism: 1) The fact that printed text contains mainly small features (high spatial frequency demand). Retinal neurons located in the periphery, because they have large receptive fields, cannot resolve the features of the individual letters. The result is an effective form deprivation of the peripheral retina. 2) The printed page contains a small range of luminance levels as compared to outdoor scenes. This smaller range of luminance results in a lower average neural activity rate. 3) Text is achromatic, whereas most scenes contain a variety of colors. It is thought that this may exacerbate the temporal effects, since the most numerous retinal ganglion cells show transient responses with a rapid course to noncolored stimuli, in contrast to a much slower decay to chromatic stimuli. Wallman et. al.[82] state that although local retinal factors seem to play a significant role in the development of myopia, other factors such as accommodation may be important as well.

Hodos et. al.[80], in their review of the literature, suggest that "extensive and prolonged stimulation of the accommodation reflex may result in stresses on both refractive and structural elements of the immature eye that result in refractive errors and alterations of the length of the optical path." Sivak[77] concluded from his interpretation of the literature that undercorrection of myopia is unwarranted and that myopia should be corrected in full as early as possible, since accommodation plays little role in myopia development. Birnbaum,[83]in a response to Sivak, contends that the axial elongation which occurs in form deprivation myopia is triggered by accommodation. Birnbaum suggests that active visual search is necessary for the development of experimental myopia, since the myopia does not occur when lid-sutured animals are raised in the dark. He also cites as evidence those studies which show a decrease in myopia development due to atropinization.[84,85] Curtin,[86] reviewing the work of Raviola and Wiesel[72], concluded that "some forms of myopia are, indeed, products of environmental impact. As such, these forms of myopia are treatable and the attempts to develop effective therapeutic regimes should be actively encouraged henceforth."

PART THREE

TREATMENT

Chapter 8.
CURRENT TREATMENT OPTIONS

There is a wide range of views among vision care professionals regarding the treatment of myopia. Not only is there a difference in view between optometrists and ophthalmologists, but also among professionals within each discipline. One thing that cannot be argued, is the fact that the incidence of myopia in our society is very high. Epidemiological and prevalence studies indicate that 24-33% of the population is now myopic.[87,88] Fledelius[89] concluded, from a large cross-sectional study, that there appears to be a real, rather than apparent, increase in the prevalence of myopia in recent years. Statistics such as these, for other health conditions, are often used to identify problems of epidemic proportions. Is myopia destined to affect our society at an ever increasing rate, or can measures be taken to prevent or control this visual condition? To answer this question, one must consider the ways that myopia is managed by vision care professionals.

For the purpose of this paper, two different approaches to vision care will be introduced. The first is a *Structural model* in which emphasis is placed on the integrity of the ocular structures and on precise refractive measurements for the neutralization of the refractive condition. The structuralist generally ignores any type of nearpoint analysis unless the patient reports significant nearpoint symptoms. Perhaps the majority of vision care professionals adhere to this mode of thinking. In general there are four types of therapy which the structuralist may suggest to the patient:

1) Concave Lenses. By far the most common approach in treating myopia, minus lenses are commonly prescribed to yield farpoint visual acuity of 20/20 or better. The patient is typically instructed to wear these lenses full time. Unfortunately, this approach seems to be the least likely to prevent furthur myopic increases.

2) Medical Treatment. Myopia control has been achieved with the use of drugs which effectively cause relaxation of the ciliary muscle tone. This mode of treatment requires long-term drug use and the use of bifocals or trifocals for all near work.

3) Orthokeratology. "Ortho K" is used to flatten the cornea in order to reduce measurable myopia. This is accomplished through the use of progressively changed rigid contact lenses which "mold" the cornea. The goal is to reduce or eliminate measureable myopia by altering the structure (shape) of the eye. This approach may be successful but "retainer" lenses may need to be worn to maintain the effect.

4) Refractive Surgery. Surgical techniques such as radial keratotomy and more recently the excimer laser are used to alter the shape of the cornea by reducing the amount of curvature to ideally yield less measureable myopia.

In a *Functional model*, emphasis is placed upon the concept that visual problems are developmental or stress-induced in origin.[90] The functionalist sees most cases of myopia as being related to the patient's environment, and is concerned with prescribing treatment strategies which will promote optimal visual function. The functionalist tends to emphasize treatment modalities which may prevent development or progression of myopia, rather than merely compensating with lenses the amount of myopia which can be measured. A smaller number of vision care professionals adhere to this mode of thinking. In general there are also four modes of therapy which may be prescribed by a functional practitioner:

1) Nearpoint lens prescription. This is considered the most appropriate prescription for near working conditions. This type of lens, when prescribed for myopes will usually produce some degree of blur at the farpoint. It is therefore often prescribed in a bifocal form or to be worn only for nearpoint tasks.

2) Vision Therapy. This mode of treatment is used by practitioners to improve the individual's visual skills. Many functional-based practitioners feel that inadequate visual skills, such as accommodation, vergence, and even eye movements are contributing factors to increased amounts of nearpoint stress and myopia development.

3) Holistic approach. Certain conditions such as physiological stress, inadequate nutrition, and psychological or emotional factors have been shown to be linked with myopia. An approach which addresses these topics is used successfully by some practitioners.

4) Visual Acuity training. Most of the research in this area has been done in the field of psychology. Many acuity training procedures are used in conjunction with vision therapy by functional practitioners when treating the myope.

Pelletier,[49] proposes that one of the real limitations of the healing professions today is that there is much more information available concerning pathology and disease than there is on health and health maintanence. It is his feeling that most of the research and clinical emphasis is on the correction of existing pathology rather than on its prevention. Although Pelletier is discussing the medical profession, it can easily be applied to vision care. Instead of only compensating for existing refractive conditions, vision care professionals may serve the public better by promoting and practicing vision maintanence and prevention.

A recent study[91] examining variables related to the rate of childhood myopia progression found that a greater amount of myopia at the initial examination age was associated with a greater rate of progression. This information shows the need to detect myopia at an early age, so that intervention can be of greater benefit to the patient. There are clinicians who use preventative methods involving a number of different types of therapy. This "integrative" approach to treating myopia attempts to address the many factors which may contribute to the myopia process. The following is a review of the most common treatment modalities, both structural and functional, used by vision care practitioners today.

Chapter 9.
CONCAVE LENSES

There are numerous sources who propose the use of minus lenses for the neutralization of the refractive condition as being the best choice when prescribing for the myope. Borish[2] states that full correction of myopia, to give the best acuity, is the most consistent form of correction. Grosvenor[92], in his address to the American Academy of Optometry on the topic of myopia, stated that: "We can continue to base our management of myopia on the prevailing conventional wisdom: prescribe minus lenses to provide good distance acuity, and prescribe visual training or bifocals when their use is indicated for problems involving accommodation or the relation between accommodation and convergence."

There are also those who propose that the application of the minus lens is at least a part of the cause of myopia progression. Rehm[93] takes a strong stand on this issue when he states: "It is the old case of treating symptoms and ignoring causes - a situation that has always prevailed in the "healing" professions. Prevention is the highest form of health care. The second highest form is treatment of existing problems by removing the cause. A poor third is the treatment or removal of symptoms but ignoring the cause. The fourth, and by far the worst form, is ignoring causes and treating symptoms in a manner that causes the basic problem to get worse. It is in this fourth category that we must place the prescription of concave lenses for acquired myopia."

Sherman[38] states that the blur experienced by the myope in the distance is not the defect. The defect is in what the patient is doing to compensate for the functional problem which occurs at near. According to Sherman the prescription of minus lenses to be worn full time is a case of treating the symptom (blur at farpoint) rather than treating the cause (near-point stress). He proposes that the minus lens acts as a "sympathetic drug" pushing the accommodative posture out, forcing the patient to continually adapt by exerting increased effort, obtained via the parasympathetic system, to bring their accommodative posture back to the plane of regard. By contrast the properly prescribed plus lens allows accommodation to posture or lag slightly behind where the eyes are pointing. Because of this lag of accommodation, there is no need for increased parasympathetic innervation, and therefore no need to call on more accommodative effort to function at the nearpoint. It is the strong feeling of some practitioner's that the application of minus lenses is the mechanism for the progression of myopia.

Kraskin[51] also stresses the importance of proper lens prescribing for the control of myopia. According to Kraskin: "One should understand that concave lenses, which provide standard visual acuity at farpoint, must represent significantly greater compensation than that required at near. In other words, use of such lenses at near is overcompensation and no different from prescribing excessive minus lenses at farpoint." Kraskin claims that if never given any concave lenses, the chances are great that the patient would propably create about 2.50 to 3.00 diopters of myopia at farpoint with no myopia measured at their near working distance.

Rehm[93] uses a dentist analogy to try to explain how harmful the prescription of full time minus lenses can be. He states: "Imagine going to a dentist with a toothache and being given medication to remove the symptom (pain) so that you again felt fine. Imagine also that the medication not only failed to stop the decay but even made the decay get worse faster. Each time the pain would begin again, you would return to the dentist for more of the same kind of treatment until finally the tooth became permanently damaged and perhaps useless. This is similar to what we are doing on a regular basis to our children's vision, merely because the errors of the past are being handed on from generation to generation."

This attitude may be extreme, but it portrays a theory which has not often been heard by the general public due to the long-standing conventional beliefs among vision-care professionals. It is obvious that the myopia problem is not improving through the use of such conventional techniques as concave lenses to improve farpoint acuity.

Chapter 10.
MEDICAL TREATMENT

The use of cycloplegic drugs to treat myopia is based on the premise that excessive or sustained accommodation leads to an increase in myopia. Because cycloplegic drugs inhibit accommodation, in theory, they should be helpful in slowing its progression. The use of these cycloplegic drugs became quite popular with those ophthalmologists who subscribed to the theory that an accommodative component is the primary factor in the development and progression of functional myopia.

Bedrossian[94] examined the effects of atropine on the progression of myopia. He chose subjects according to two criteria: age (8-13 years), and rate of myopia progression (increasing more than .50 D annually). To compare the effects of heredity and environmental factors, one eye was used as a control for one year while the fellow eye was treated with 1% atropine at bedtime every night. The following year, the eye initially used as a control became the test eye, and the original test eye was the control eye. For 75 subjects, the results showed average change of refractive condition to be +.20 D for the treated eyes and -.85 for the control eyes. At the end of the second year, in which treatment was switched to the fellow eye, the average change in refraction was +.17 for the treated eyes and -1.05 for the control eyes. A study by Dyer[95] using 1% atropine instilled daily in 230 eyes of 115 children, showed that 47% of the atropine treated eyes and 2% of control eyes had no change or a reduction in the amount of measureable myopia.

Abraham[96] suggested that tropicamide was useful in the treatment of progressive myopia, and that it is preferable to longer acting cycloplegics such as atropine. His results for subjects ranging in age from 7-18 years, using tropicamide instilled daily at bedtime, showed 29.4% of treated eyes and 62.8% of the control eyes had increased more than .50 D of measureable myopia. When only those subjects 13 years or younger were considered, 36.5% of the treated eyes and 81.7% of the control eyes showed mean changes greater than .50 D.

Goss[97] claims that although the results of some cycloplegic studies appear encouraging, atropine cycloplegia does present a difficult visual environment due to an inability to accommodate and enlarged pupils. These difficulties are compounded when only one eye is cyclopleged, due to a decrease in binocular function, as well as the added visual stress caused by the increased effort required to function at the nearpoint task. Sampson[98] has noted that medical treatment of myopia was very unpopular with his patients. In addition to the problem of compliance, he questions the safety of using this type of treatment on a long-term basis.

Chapter 11.
ORTHOKERATOLOGY

In the 1950's practitioners began to notice an apparent arrest, and in some cases a reduction, in the amount of myopia progression in the presence of hard contact lens wear. Due to an increased interest in this phenomenon, Jessen helped found the Society of Orthokeratology in 1962. Grant and May[99] presented a paper entitled "Emmetropization through Contact Lenses" in which the first protocols for orthokeratology procedure were developed. Today it is estimated that over 100,000 North Americans have been treated through the use of orthokeratology.[100]

Grant and May[101] have defined orthokeratology as "The reduction, modification, or elimination of a visual defect by the programmed application of contact lenses or other related procedures." Although there are a number of orthokeratology techniques[102] used, the basic premise for treating myopia is that a flat-fitting contact lens acts to effectively flatten the corneal curvature resulting in a point of focus closer to the retina. The patient is generally seen on a regular basis so that appropriate changes in the prescription and or contour of the lens can be made. At the end of treatment, the goal is to have a patient who is less dependent, or totally independent, of optical aids. In order for the effect to be permanent, retainer lenses must be worn for a part of each day to stabilize the corneal flattening.[103] The procedure has been shown to be most successful with those patients whose myopia is less than 2.50 D,[1] and reductions in measureable myopia have been shown for patients of all ages.[103,104]

Numerous studies have been published on the topic of orthokeratology. A five year study by Stone[105] compared the progression of myopia in eighty myopic contact lens wearers with that of forty myopic spectacle lens wearers. Stone used a conventional apical clearance fitting scheme with rigid corneal contact lenses. The progression of myopia was closely monitored in growing children after two years of lens wear. The results of Stone's study showed four areas of significant interest: 1) the myopia of spectacle lens wearers increased by an average of 1.75 D over a five year period, 2) with-the-rule astigmatism also showed a slight myopic increase of .38 D in the spectacle lens wearing group, 3) the myopia of the contact lens wearing group showed an average decrease of .12 D over the five year period, and 4) with-the-rule astigmatism increased by .87 D in the contact lens wearing subjects.

Stone concluded from his study that axial length elongation and possibly an increase in crystalline lens power were the primary mechanisms involved in myopic progression for the spectacle lens wearers. Corneal lens power as measured with keratometry did not show a significant change. The corneal curvature in the contact lens wearers flattened, resulting in decreased corneal power and a subsequent reduction in myopia. Because the reduction of measureable myopia could not be explained by corneal curvature alone, Stone suggests that contact lenses may have additional effects on the visual system, such as inhibition of axial elongation or decreased crystalline lens power, to account for the reduction of the refractive power of the eye.

Kerns[106] performed a controlled study designed to challenge the validity of orthokeratology. The study consisted of two control groups (three non-contact lens wearers and thirteen conventional contact lens wearers) and one experimental group (n=18) that underwent orthokeratology treatment. The subjects ranged in age from ten to thirty years. Results of the study showed that both contact lens groups underwent changes that were significant when compared to the non-contact lens wearers. The orthokeratology group underwent changes which were significant compared to the conventional contact lens group. The orthokeratology group showed an improvement in visual acuity and a refractive state which decreased in minus, especially with the spherical equivalent refraction. When the refractive state of the three groups was compared, it was found that the spectacle control group increased slightly in myopia, whereas the two contact lens groups decreased in myopia, with the orthokeratology group showing the largest amount of reduced myopia. From these findings, Kerns speculated that perhaps orthokeratology only accelerates the changes which would ordinarily take place with rigid contact lens wear.

In his analysis of the results, Kerns was cautious to point out that corneal modification with contact lenses is still not clearly understood. The study revealed the following trends: 1) regardless of the base curve-cornea relationship, the horizontal corneal curvature showed a tendency to flatten, 2) in the vertical corneal meridian, a flattening occured when lenses were fit greater than .50 D flatter than "K", 3) the flatter the fit, the greater was the probability of observing increased corneal toricity, 4) the resulting with-the-rule astigmatism appeared to be an uncontrollable consequence of the orthokeratology, and 5) the limits of myopia reduction were affected by the ocular rigidity of the cornea. In conclusion, Kerns stated that, "...Orthokeratology is very much an individualized process and is likely to remain so until factors important to the process are positively identified and quantified. Only when the mechanism for corneal change following contact lens wear is fully understood will there be less myopic views of orthokeratological procedures."

Paige and Mustaler[104] reported a study of 75 orthokeratology patients who were followed for two or more years after orthokeratology treatment. The results showed an average change in spectacle Rx of 1.74 D less measureable myopia with an increase of .29 D of with-the-rule corneal toricity. They reported that for each diopter of corneal flattening of the flatter K, the myopia was reduced by 1.93 D. According to this study, "low-range myopes (-1.75 D or less) can expect to achieve emmetropia and 20/20 unaided visual acuity, or close to it." Also, Paige and Mustaler report success for low range myopes with only four to six hours of wearing per day. They conclude that "for optimum benefit, whenever possible, treatment should begin while the individual is still a low-range myope."

Morrison[107] feels there are a number of factors, besides corneal changes, involved in myopia control through the use of contact lenses: 1) the contact lens retains the curvature of the cornea, 2) the contact lens produces a holding effect on any stretching of the eyeball, 3) contact lenses do not have the same prismatic effects and accommodative - convergence relationships as spectacle lenses have, 4) contact lenses produce a larger retinal image size than do spectacles, 5) contact lenses afford a better depth of focus due to smaller pupil size, and 6) they provide a wider field of view than spectacles. Morrison believes that the daily wear of rigid contact lenses has an arresting effect on the progression of non-pathological myopia.

Greenspan[108] proposes that it is possible that minus lenses in spectacles may give a minifying effect, causing the patient to bring near work closer in order to offset this minification. This would require more accommodation and could lead to functional myopia. Contact lenses may act to eliminate this minifying effect, causing a decreased rate of myopia progression. There are some practitioners who combine orthokeratology with other myopia prevention or reduction techniques. Bastien[109] states "the orthokeratologic effect is not meant to replace, but to complement stress-relieving lenses." Bastien terms his treatment program "global orthokeratology," the basic treatment plan is to add the perceptual and mechanistic advantages of contact lenses to the physiological benefits of stress relieving lenses and vision therapy and, when indicated, nutritional counseling. Barksdale[110] has shown increased levels of myopia reduction when vision therapy was performed in conjunction with orthokeratology.

Meier[111] raises some interesting questions concerning the results obtained with contact lenses: a) Do contact lenses really inhibit myopia development, or do optometrists usually fit patients who are coincidentially at the end of their growth pattern, when their eyes begin to stabilize? b) Or are most new contact lens patients fitted when they are coincidentally finalizing their formal schooling and are therefore experiencing reduced stress on their visual system?

Perhaps the major criticism of orthokeratology is the concern that once the treatment is concluded, and the the lenses removed, the effect of the procedure wears off.[103] Other criticisms of orthokeratology include its effect on the health of the eye,[1,103] a tendency to induce with-the-rule astigmatism,[103] and the possibility of inducing irregular astigmatism and corneal warping.[1]

Proponents of orthokeratology are quick to point out the benefits which can be gained through the use of this treatment modality. Grant[112] states that orthokeratology can provide benefits for people with a desire to see better without optical aids, for people whose occupations may require specific unaided visual acuity, and for people who desire to be less dependant on external devices for normal vision. Grant also points out that orthokeratology should not be ruled out for higher myopes (over 5.00 D) just because 20/20 visual acuity may not be obtainable. He states "To improve visual acuity from worse than 20/400 to 20/50 is of great value to these individuals in that they are no longer totally dependent on lenses for adequate vision for normal functions, and can still perform most activities if anything should happen to their lenses." Grant also mentions the role which properly administered orthokeratology can play in myopia prevention.

Chapter 12.
REFRACTIVE SURGERY

A number of refractive surgical techniques are presently used for the correction of high myopia. Surgical procedures currently used include; 1) Radial keratotomy, 2) Keratomileusis, 3) Epikeratoplasty, 4) Anterior chamber lens implantation in phakic eyes, 5) Hydrogel, polysulfone, or polycarbonate intracorneal lenses, 6) crystalline lens extraction, and 7) Excimer laser corneal lathing.[113,114] Radial keratotomy and excimer laser corneal lathing have generated a high level of interest in the past decade within the eyecare profession. Because of this high interest level, I have chosen to review only these two surgical procedures. Although refractive surgery is a non-optometric treatment mode, it's wide use in this country justifies it's inclusion in this review. A comprehensive review of the other refractive surgery procedures can be found elsewhere.[113]

Radial keratotomy is an experimental surgical procedure used to reduce the amount of measureable myopia. The procedure involves making four to sixteen radial incisions through 90-95% of the corneal thickness. The diameter of the unoperated central clear zone is mainly dependent on the pre-operative refractive condition of the patient. The higher the amount of preoperative myopia, the smaller the central clear zone must become. The proposed mechanism for the reduction of the refractive condition is through the weakening of the peripheral cornea, which allows the intraocular pressure to cause this area to bulge, thereby making the central cornea relatively flatter. This of course results in a new point-light focus of the eye, which would be located closer to the retina resulting in less measureable myopia.

The procedure was introduced by Sato in Japan during the early 1950's.[115] The original procedure involved making incisions into the posterior cornea as well as the anterior cornea. Follow-up studies of these patients revealed significant amounts of endothelial damage and bullous keratopathy, sometimes resulting in blindness.

In the early 1970's a Russian ophthalmologist, Fyodorov, reported successful results using sixteen radially oriented incisions made only into the anterior cornea.[116] This new technique was introduced in the United States by Dr. Leo Bores in 1978.[115] Dr. Bores founded the National Radial Keratotomy Study Group to investigate the use of this procedure on a widespread basis. By 1986, more than 200,000 radial keratotomy operations had been performed in the U.S.[113], with very little previous research or animal studies to prove its effectiveness and safety.[115]

Due to a lack of clinical research concerning this procedure, the National Institute of Health funded the Prospective Evaluation of Radial Keratotomy (PERK). The study began in 1980 as a nine-center clinical trial of a standardized technique on 435 eyes having a presurgical myopic refractive condition between 2.00 and 8.00 diopters with no more than 1.50 diopters of astigmatism. The technique consisted of eight incisions using a diamond micrometer knife with blade length determined by intraoperative ultrasonic pachymetry and the diameter of central clear zone determined by preoperative refraction.[117] Due to this study, RK became officially classified as an experimental procedure.

The PERK study showed that 2 years post-surgically, 1 in 4 patients had a different refractive result in each eye. 1 in 3 patients showed unstable refractions 2 years after surgery was performed.[115] The study also indicated that 90% of all patients had a final refractive condition within 1.75 diopters of emmetropia one year after surgery.[117] For cases which do not respond favorably, a second procedure is often performed. The percentage of cases requiring a second operation varies from 7.7% to 11.9%.[118,117,119] Reports of 15 to 26% of patients requiring full-time wear of corrective lenses post-operatively lead Binder[120] to conclude that long-term discontinuation of spectacles is unlikely.

The major complication of RK surgery seems to be the unpredictability of the final refractive condition for each patient. Other major concerns include unstable vision and the possible effect that future trauma, inflammation, disease, and cataract surgery may have on the eye.[113,116] Ocular complications of RK which have been cited in the literature include; over and undercorrection, induced regular and irregular astigmatism, early onset of presbyopia, loss of best corrected acuity, corneal perforation, endophthalmitis, cataract formation, a decrease in corneal tensile strength, epithelial ingrowth, endothelial cell dropout, ulcerative keratitis, recurrent corneal erosions, iritis, and hyphema.[120,121,122,117,119,115] Subjective postoperative complaints reported in the literature include glare, photophobia, monocular diplopia, and unstable visual acuity.[120]

Patients who choose to undergo a radial keratotomy operation because they no longer want to wear spectacles may, in actuality, have spectacles as the only choice for 20/20 corrected visual acuity. Contact lens fitting after radial keratotomy is controversial, and if done at all, should be approached with extreme caution. A potential for corneal vascularization exists along the corneal scars with soft contact lens wear.[123] Placing a contact lens on an already traumatized cornea, may result in furthur corneal damage such as a delayed keratitis or bullous keratopathy.[124,125]

Functional considerations must be taken into account as well. It has been documented that myopic shifts in refraction can occur well into the patient's 20's or 30's, mainly due to accommodative spasm or nearpoint stress. A person who is involved in an occupation requiring extensive nearpoint demands upon the visual system may continue to show changes even after a successful RK operation.

Long-term effects of radial keratotomy are still not known. It should be understood that radial keratotomy is an experimental procedure. High myopes would seem to be the group which could be helped the most, yet studies show that the procedure is most effective for patients with 2.00 to 5.00 diopters of myopia.[115,119,120]

Research is currently being done on animals and enucleated human eyes to investigate a new technique which involves the use of an excimer laser to create a new anterior corneal curvature in an attempt to eliminate myopic conditions.[126] The technique involves accurately calculated nonuniform removal of large areas of anterior corneal tissue to correct refractive errors. The advantage of the excimer laser technique over that of RK, would be the ability to provide more accurate incisions (in length and depth), and a reduced amount of anterior corneal scarring.

Of the previous four areas of myopia therapy, three of them (minus lenses, orthokeratology, and radial keratotomy), emphasize relief of the main symptom of myopia, which is distance blur. The use of cycloplegic drugs, although aimed at solving the nearpoint problem of overaccommodation, disrupts the normal physiology of the eye. Attention will now be turned toward functional modes of myopia therapy. The functionalist attempts to treat the underlying problem which may be causing the symptom of distance blur. The goal of functional therapy is prevention, control, and in certain cases reduction of the myopic visual condition, without compromise to the structural or physiological properties of the eye.

Chapter 13.
NEARPOINT LENS PRESCRIPTION

Structural or classical optometrists commonly prescribe concave lenses for myopia to restore optical conjugacy to an out-of-focus visual system. Typically the lenses are prescribed for constant wear and provide standard visual acuity at the farpoint. Nearly all early myopes who receive these lens prescriptions are school age children who spend a considerable part of each day being subjected to the near demands of our educational system. Conventional wisdom tells us that these extended near point activities at school are of little concern clinically due to the large accommodative amplitude which school age children possess. Conventional wisdom also tells us that these children will likely become more myopic throughout their school years due to the normal growth patterns of the eye.

Functional or behavioral optometrists commonly prescribe convex lenses at near as a means to prevent myopia or to control its progression. The functional optometrist views myopia as an adaptation by the individual to his environment. In the case of myopia, the individual sacrifices distance visual acuity in order to function more effeciently at near. The biologically unacceptable task of sustained nearpoint activity is considered to be the cause of many stress-induced visual problems. Myopia is viewed simply as being one mode of adaptation to this problem. Kraskin[51] claims that when discussing a patient as being myopic, it must be described as myopia for a given distance. When myopia initially emerges as the mode of adaptation, visual acuity is found to be substandard at farpoint yet is standard at near. For this patient it would be proper to state that the myopia is found at farpoint but not at near.

To fully understand the proposed benefits of a nearpoint lens prescription, one must first understand the effects produced by a concave lens.

A concave lens increases the tonicity of the body's postural musculature, reduces visual space volume, emphasizes figure as opposed to ground, and alters the distribution of light so as to produce a size reducing effect.[127] Because objects appear smaller when viewed through a concave lens, the observer is apt to compensate by decreasing the viewing distance. Bastien[128] has emphasized the importance of the habitual working distance as it relates to myopia. He claims that the concave lens produces a "smaller-in" effect, which is a contradiction to the usual "larger-in" effect that occurs when an object is moved closer to the observer. It is the strong belief of Bastien that the tendency to move the print closer toward self, which he terms as a "behavioral disposition to operate esocentrically in space", is an early sign of myopic behavior. When the myopia is compensated with concave lenses prescribed for constant wear, a reduction of image size occurs resulting in a furthur reduction of the working distance as well as a greater esocentric drive at near. Along with the decreased working distance and the smaller-in effect of concave lenses is a stimulus for increased accommodation. The association between accommodation and convergence then results in a still greater esocentric drive by the individual, and the cycle repeats itself. Bastien claims "the optical means utilized to compensate absolute myopia are by nature myopiagenic."

In contrast to a concave lens, the convex lens reduces tonicity of the body's postural musculature, expands visual space volume, emphasizes background as opposed to figure, is size enlarging, and carries a "larger-out" effect.[127,129] A convex lens has the effect of increasing the individuals working distance, by allowing accommodation, and therefore convergence, to posture furthur away in space. If in fact an esocentric shift does occur with progressive myopia[130], the usefulness of a convex prescription is clear. Of course little value can be found in a nearpoint prescription if one believes that myopia is simply an elongated eyeball due to certain genetic or biological traits.

In recent years a number of scientists have investigated the possible mechanisms involved in the nearpoint visual process. Press[127] has reviewed the work of a number of these investigators. It has been theorized that the accommodative-convergence control system consists of two loops:

The first loop is a negative feedback loop which simply enables vergence to maintain a common visual direction while accommodation acts to minimize blur. The controllers of this loop, blur and disparity, take only milliseconds to complete their responses.[127]

The second loop is a feedforward adaptive loop which enables visual adaptations through tonus control of the resting level of accommodation and vergence. This loop consists of two feedforward paths, accommodation-convergence (A/C) and convergence-accommodation (C/A), which act to coordinate one another. The controller of this loop, tonus, is slow, taking minutes or even hours to complete its response. Visual adaptations may occur when the slow controller reacts to a point which causes change in the resting level of accommodation-convergence. This type of change would result in changes or shifts of the phoric posture and the refractive condition. Ebenholtz[131] claims that minus lenses at distance result in adaptive shifts of the slow controller, while proper plus lenses at near would defuse adaptive shifts by partially discharging the slow controller to re-establish baseline levels of dark focus and vergence.

The resting level of accommodation, or dark focus has been shown to be approximately one meter. Ebenholtz[132,133] has shown in studies that a shift of the dark focus occurs in the direction of effort with sustained near work. Associated to this shift is a hysteresis effect which results in the maintanence of this new position of dark focus for an amount of time after the near work has been completed. Owens et.al.[134] have proposed that inward shifts of tonic accommodation serve to relieve the effort required by strenuous nearpoint visual tasks.

Birnbaum[135] has reported from personal clinical experience that typical signs of early myopia are; increased nearpoint esophoria, an increased PRA, reduced NRA, decreased level of accommodative facility, as well as reduced distance acuity. It is possible that a sympathetically induced inward shift of the accommodative resting level results in a new "baseline setting" for the visual system which is nearer in space than what is optimally desired. This change in the tonus level of the visual system may occur in order to compensate for the parasympathetically induced levels of increased accommodation and convergence associated with the nearpoint task. This may be the mechanism causing the clinical changes reported by Birnbaum.

According to conventional wisdom, the accommodative system is fully relaxed while viewing infinity. Ebenholtz has shown that if near work is done at a distance which corresponds to the dark focus of accommodation, no inward shift (esocentric drive) occurs. This lends evidence to the theory that the accommodative dark focus is actually the relaxed or stress-free position. Because this resting level is normally at one meter, it is impossible to advise patient's to do all nearpoint work at this distance. Convex lenses are prescribed in order to move the accommodative posture outward in space toward this stress-free position. Because the dark focus has been shown to be highly variable between individuals, it is vital to prescribe on an individual basis according to some form of nearpoint analysis.

A number of studies have investigated the usefulness of nearpoint prescriptions, mainly in bifocal form for young progressive myopes. The use of a bifocal lens allows the myopic patient clear distance acuity while still providing the properly indicated lenses for nearpoint work. Mandell[136] conducted an extensive eleven year study comparing the rate of myopia progression among 175 myopes. 59 of the myopes had at some time worn bifocal lenses. The results of the study showed a progression of myopia in 91% of the bifocal group, while only a 76% progression rate was noted among the non-bifocal wearers. Furthur inspection of the Mandell study, shows an initial refractive condition of 2.75 diopters and an initial age of 14.3 years among the bifocal group, while the initial refractive condition of the non-bifocal group was 1.48 diopters with an initial age of 17.1 years. This study shows the need for a more controlled bifocal study in which such factors as age difference, nearpoint phoria, accommodative findings, sample size, differences between males and females, and possible investigator bias are considered.

Roberts and Banford[137] conducted a study to compare the rate of myopia progression among bifocal wearers and non-bifocal wearers of similar age and refractive status. The study consisted of 226 male patients and 305 female patients. No attempt was made to match the single vision group and the bifocal group in age, sex, or amount of myopia. Evaluation of the study reveals a progression rate of -.401 D per year for the single vision wearers, and -.314 D for the bifocal wearers, a 22.8% retardation in the progression rate for the bifocal group. The authors found a reduced myopia progression rate among the female bifocal group as compared to the female single vision group, yet no reduction was found among the male bifocal group. Roberts and Banford suggest from their study that a reduction in the myopia progression rate is more likely with bifocal lenses if esophoria at far and near and a high AC/A ratio are present. A possible flaw in study design may be the application of arbitrary bifocal adds instead of a prescription based on an individual nearpoint analysis.

Oakley and Young[138] in a controlled study on bifocal control of myopia attempted to control such variables as sex, initial age, and initial refractive condition while following the subjects over a number of years. 266 Caucasian children of the same age were compared to a similar non-bifocal control group with 192 subjects. Flat top bifocal adds were prescribed so that the add intersected the pupil center. The typical prescription called for a .50 D undercorrection at distance and a +1.50 to +2.00 add. The investigators found that the children wearing bifocals showed an overall myopic progression rate of .04 D per year, while the non-bifocal group showed a progression rate of .53 D per year. The overall annual rate of progression for the bifocal group was 8% of that shown by the non-bifocal group. Oakley and Young attribute the success of the bifocal group to the very high position of the add fitted to each child. According to the authors the low annual rate of progression found among the bifocal subjects suggests that bifocals are having a controlling and reducing effect upon the rate of progression.

Chase and Edmunds[139] conducted a study comparing two optometric vision care practices. One practice used full "correction" lenses to compensate for myopic refractive conditions while the other practice used plus addition lenses designed to control the progression of myopia. The results of their study showed a significant difference in the progression rate of myopia in the 100 patients studied from each practice.

Both practices prescribed lenses according to their own particular model of vision. One practice taking the view that refractive conditions are of a genetic origin, and therefore myopia and its progression cannot be controlled. Typical treatment of myopia, within this practice, consisted of a least-minus to best visual acuity subjective refraction with a trial frame procedure to determine the final prescription. The practitioners in the other practice view myopia as being environmentally induced and therefore controllable through the use of properly prescribed lenses. Their treatment of myopia consisted of a least-minus to best visual acuity subjective refraction, but then utilized a functional syndrome analysis of the analytical findings in order to determine a final prescription. This analysis was used to determine a proper plus addition for nearpoint visual tasks.

To investigate the two opposing points of view, two practices were chosen from the same geographic area (six miles apart). Because of the proximity of the two practices, the patient populations were similar; with many attending the same schools, having similar socio-economic backgrounds, and being exposed to similar environmental conditions. Data were obtained on a minimum of 100 patients from each practice. The criteria for patient selection were as follows: 1) An initial refraction not exceeding +1.00 D of hyperopia or -2.25 D of myopia, 2) Cylinder not to exceed -1.50 D on the initial refraction, 3) Between 5 to 16 years of age, and 4) patients must have been examined at least twice during the chosen age span.

Statistical analysis of the results show a significant difference in the rate of myopia progression between the two practices. Results of the study show:

1. 91.2% of the patients from the full correction practice showed an increase in myopia, while only 62.3% of the patient's from the plus addition group showed an increase.
2. The mean rate of myopia progression per year was -.248 D for the full correction lens practice and -.089 D for the plus addition practice.
3. Patients from the full correction practice had an average refractive condition of between -1.50 D and -1.75 D at age 16, while the average refractive condition of the 16 year old patient's from the plus addition group was plano to -.50 D.

From their study Chase and Edmunds conclude that "The plus addition program had a strong effect in controlling myopia in prepresbyopic patients."

Recently Goss and Grosvenor[130] reported on three previous bifocal studies in which the data were reanalyzed. In all three studies the rate of myopic progression with bifocals was found to be significantly less than with single vision lenses for cases in which nearpoint esophoria was present. Progression rates were found to be similar for the two groups in patients who had nearpoint orthophoria or exophoria. These findings are consistent with the behavioral model of vision which states that myopia is an adaptation to nearpoint visual stress. This nearpoint stress causes a sympathetically induced increase in the lag of accommodation, resulting in overconvergence (esophoria) at near.

It must be noted that flaws do exist in many of the bifocal studies which have been cited in the literature. Oftentimes no mention is made of the bifocal seg placement or of the criteria which were used to select the nearpoint lens prescription. The selection of an arbitrary near addition may actually result in a visual system becoming less efficient at nearpoint than before the bifocal was prescribed. The fact that a greater amount of myopia at the initial examination age was associated with a greater rate of myopia progression indicates the importance of early detection, and the need for greater control of initial refractive status in future studies. Ideally a study in which all subjects are "pre-myopes", who have never been exposed to concave lenses, would be a stronger indicator of the usefulness of a nearpoint prescription in the prevention/control of myopia.

Chapter 14.
VISION THERAPY

Vision therapy is used by many practitioners to improve the efficiency of the visual system. An inefficient visual system cannot withstand the environmental stresses caused by sustained nearpoint work. These same environmental stresses have been implicated by Birnbaum[140] and others as a possible cause of functional myopia. In fact the earliest forms of optometric vision therapy actually began with William Bates and his Sight Without Glasses concept[141], which was primarily aimed at treating myopia.

There is a lack of controlled studies in the ophthalmic literature which investigate the effectiveness of vision therapy in controlling myopia. Many of the studies which have been published and often cited, involve the use of vision therapy as the sole mode of therapy. One such study is the infamous Baltimore Myopia Study conducted in 1944. The Curtis Publishing Company funded this study which consisted of 111subjects ranging in age from 9 to 32, and having from .50 D to 9.00 D of myopia. The therapy was administered by a group of optometrists headed by A.M. Skeffington. The results of the therapy were evaluated by ophthalmologists at the Wilmer Institute.

Woods[142] reported the official ophthalmological views concerning the Baltimore Study in 1945. Despite an average increase of one to three Snellen lines of acuity, Woods believed that the improvement was due mainly to an improved ability to interpret the blurred retinal image. Woods stated, "with the possible exceptions of educating some patients to interpret blurred retinal images more carefully...this study indicates that the visual training used on these patients was of no value for the treatment of myopia."

A report by Ewalt[143] in the *Journal of the AOA* indicated that 90% of the subjects that finished the study showed significant visual acuity improvements with both eyes. Ewalt concluded from his report, "The evidence is conclusive that optometric methods of visual training improve the visual acuity of most myopes, unselected and unmotivated."

An ophthalmological study by Hildreth et. al.[144] in 1947 attempted to improve the visual acuity of 54 selected myopia cases through the use of a vision therapy program preceded and followed by an ophthalmologic examination. In the study 30, or 55.5%, of the cases showed no change in their acuity, while 12, or 22.2%, showed a definite improvement. The best results occurred in the cases of low myopia of one diopter or less (55% improvement). Hildreth et. al. summarized that "visual training has a definite, but limited value in some myopic patients and that visual training merits further study from the ophthalmologist particularly in relation to myopia."

Another ophthalmological study by Berens et. al.[145] was carried out with 140 myopic subjects. Of these, 80 received tachistoscopic visual training and 60 were given an initial and final vision examination, but no visual training. The subjects ranged in age from 10-30 years of age and were from .50D to 3.50D myopic with no more than 2.50D of astigmatism and 2.00D of anisometropia. The two groups were carefully matched in age, sex, education, socio-economic status, and initial visual measurements.

Both groups received pre-examinations by ophthalmologists, which included retinoscopy under cycloplegia, visual form fields, visual acuity, retinal rivalry rate, motility studies, and routine internal examination of both eyes. The experimental group then received three tachistoscopic visual training sessions per week for ten weeks. At the completion of training both groups received final examinations identical to the initial exams.

The final results indicated a statistically significant trend toward improvement in visual acuity, size of visual form field, refractive error, and reading speed in the experimental group, with a similar significant trend toward deterioration of these same visual skills in the control group. More specific results of the study include;

1) 93% of the experimental group improved in uncorrected visual acuity The average increase was approximately four lines on the AMA test chart. Average increase in acuity was 20/128 to 20/79 (O.D.), 20/121 to 20/75 (O.S.), and 20/98 to 20/63 (O.U.).
2) 98% of the control group showed a loss of visual acuity. Average loss in acuity was 20/110 to 20/157 (O.D.), 20/120 to 20/157 (O.S.), and 20/97 to 20/131 (O.U.).
3) The changes in refractive error were an average myopia reduction of .22D for the experimental group and an average increase of .29D for the control group. 69% of the experimental group showed some reduction while 79% of the control cases had some increase.

With the results obtained by these and other early studies of the role of vision therapy in the management of myopia, it is surprising that the topic was, for the most part, put to rest. The early studies were conducted on pre-existing myopes only and relied on vision training as the sole means of therapy. Many of today's practitioners who use vision therapy as a means to control functional myopia, do so in conjunction with other forms of intervention such as a nearpoint lens prescription, orthokeratology, nutritional consultation, or stress reduction therapy. A few practitioners have written on this topic, and have described their approach to using vision therapy as a part of a complete myopia control program.

Birnbaum[3,135] considers vision therapy an important aspect (along with a properly prescribed nearpoint prescription and visual hygiene advice) of a complete myopia management program. Birnbaum claims, "vision training may be effective in the creation of a more efficient visual system, with improved accommodative skills, to better withstand stress on the accommodative system." Furthur, "vision training may be quite effective on a preventive basis in patients showing early signs of myopia development."

Birnbaum emphasizes vision therapy techniques which use cycles of accommodative stimulation and relaxation. He claims it is important for the patient to develop adequate skills in the relaxation as well as the stimulation of accommodation, so that both can be done easily and effectively.

The tendency toward overconvergence, according to Birnbaum, is commonly seen in nearpoint stress cases and likewise with early myopes as the result of a need for an excessive amount of innervational output in order to accommodate. The goal of therapy is to place the accommodative and convergence systems in balance by increasing the freedom of action between the two systems. Birnbaum accomplishes this by using fusion range extension techniques, binocular accommodative rock with fusion controls, "BOP-BIM" techniques, and stereoscope tromboning techniques.

Another important use of vision therapy for the functional myope is to teach the patient to relax their accommodative system and to increase plus acceptance at near. Techniques used by Birnbaum to aid the patient in attaining these skills include clearing increasing amounts of plus lens power during accommodative facility training and during distance vision tasks.

Another aspect of Birnbaum's approach to managing functional myopia is the use of general relaxation or stress reduction techniques[146]. Much on this topic will be discussed in the holistic therapy section of this paper although one area which Birnbaum emphasizes, peripheral awareness, is best addressed in this section. It has been theorized that under stress the visual periphery is constricted[53]. Birnbaum believes maintanence of peripheral awareness requires a relaxed attitude and passive concentration, therefore vision therapy techniques which emphasize peripheral awareness can be used to foster relaxation. Some techniques used to enhance peripheral awareness include the Wayne peripheral awareness trainer, the MacDonald form recognition card, binasal occlusion training lenses, and tachistoscopic training.

Friedman[147] summarizes his approach to the management of myopia through the use of a vision therapy program combined with correction spectacles, training spectacles, and control of environmental factors (vision hygiene). His program consists of 10 to 12 weekly one-hour in office sessions, in addition to 30 minutes of daily home training.

Friedman uses a number of techniques to teach control of the accommodative system. Patients are taught that "on accommodation" represents active accommodation which is stimulated by nearpoint objects or any blurred object which requires identification. On the other hand, "off accommodation" represents a relaxation of the accommodative system. All patients are taught voluntary control of accommodation so that they are able to stimulate and inhibit their focusing mechanism. It is also stressed to each patient that clearer vision is produced by maximum relaxation of the accommodative system.

Voluntary control of the vergence system is also taught to each patient. Various instruments and techniques are used for anti-suppression training, with the goal being awareness of suppression and the ability to regain binocular vision within a brief period of time. Large amounts of base-out and base-in prism are used in lens holders (flippers) to view a stationary object, such as a marsden ball. The patient is told to be aware of the diplopia which occurs when the prism is briefly placed before the eyes so as to not allow enough time for fusion to occur. The eventual goal is to train the patient to allow diplopia through decreasing amounts of prism while resisting the sensory motor fusion response. When this is accomplished the patient has learned to inhibit fusional vergence.

Daum[148] conducted a study to examine the effectiveness of optometric vision therapy on negative vergence. After a thorough initial visual examination, two adult subjects (ages 22 and 25 years), were prescribed a vision therapy program consisting of two 45-minute sessions per day on the weekdays of 7 consecutive weeks. The training was exclusively negative vergence training. Daum concluded from the study that it is indeed possible to produce substantial changes in the negative vergence capabilities of a subject. The study indicated that approximately 10 to 15 hours of training is necessary to achieve maximum results.

Friedman believes that those patients who demonstrate a significant nearpoint visual dysfunction (ie. low PRA, accommodative spasm, convergence insufficiency, divergence excess, convergence excess) will be more likely to show a stabilization in their refraction after the visual skills are enhanced through the use of vision therapy. Friedman has also observed that amblyopic patients demonstrating functional myopia in their nonamblyopic eye will respond successfully to therapy.

Kraskin[149] uses vision therapy as one alternative of care for his myopic patients. He operationally classifies myopes into three categories; 1) those who have never worn compensatory lenses for distance, 2) those who have compensatory lenses but only use them selectively for distance, and 3) those who wear compensatory lenses for full-time wear. According to Kraskin the first category of myope has an excellent prognosis for improvement and altered behavior, the second category has a good prognosis for improvement, while the third category has a poor prognosis for improvement.

Kraskin[141] cites two major reasons why a myope may be considered for visual training in his office; 1) control of myopic progression and 2) distance vision improvement. He states that, "visual training is <u>not required</u> for every progressing myope and the distance vision of <u>some</u> myopes can be improved by means of visual training."

The myopia visual training program used by Kraskin, is similar to his visual training program for any other visual problem. The goal being to develop a more efficient and effective visual system. With the myope various aspects of visual performance will be emphasized depending upon the individual. Some specific procedures used by Kraskin include; "deep wink" and "plateau spiral". Throughout the myope's visual training program, Kraskin emphasizes the importance of kinesthesia, feeling, and patient awareness of what he or she is doing. The goal is a patient who will ultimately have the ability to control his environment, rather than be controlled by his environment.

Harris[150] believes that accommodative-convergence fatigue, as a result of nearpoint stress, is a major factor in myopia progression. Therefore vision therapy aimed at putting these two effector systems into balance, at least in theory, should halt myopic progression to some extent. Harris cites three case examples of patients who were treated successfully through the use of orthokeratology, nearpoint lens prescription, proper environmental control, and accommodative-convergence vision therapy. Techniques used by Harris include accommodative lens rock, near-far accommodative rock, eccentric circles, and other home based convergence training.

There is a definite lack of documentation in the optometric literature regarding vision therapy as a treatment option for myopia. In his concluding remarks at the American Academy of Optometry symposium on myopia, Birnbaum[151] stated, "clinical experience indicates that vision training can be an effective tool to improve accommodative abilities, increase freedom between accommodative and vergence systems, promote behavioral changes related to accommodative relaxation, and hence add substantially to the effectiveness of myopia management." Vision therapy needs to be further investigated as a viable part of any total myopia management program. Many studies in the past have examined the usefulness of vision therapy, by itself, as a treatment mode. Vision therapy alone is not the answer when treating myopia. It may, however, be an important part of the answer, especially for myopia prevention and visual skill enhancement to withstand the environmental stresses associated with sustained nearpoint work.

Chapter 15.
HOLISTIC THERAPY

Over the past 10-15 years there has been a movement in our society towards a more humanistic approach to health care. People are assuming the responsibility of educating themselves concerning nutrition, exercise, stress reduction, and emotional well being. People are becoming active participants in their health care. Instead of feeling like a helpless patient at the mercy of whatever the doctor decides to prescribe, more and more people are actively involved in their own preventative health maintanence programs. This heightened health awareness can be seen all around us by observing the large number of joggers in our country, the ever-increasing number of organic food markets, the number of vegetarian dishes on restaurant menus, and the growing popularity of health and fitness clubs across the country.

The term holistic is defined as a state in which an individual is integrated in all his levels of being: body, mind, and spirit.[152] Consideration of the whole person emphasizes the healing process, the maintenance of health, and the prevention of illness rather than the treatment of established disorders. According to Pelletier, this concept of holistic, preventative health care is one of the most important innovations in modern medical research and its clinical applications.[49]

With the advent of antibiotic medicines in the last fifty years, stress-induced chronic disorders have replaced infectious disease as the major medical problem of the post-industrial nations.[49] Often described as afflictions of civilization, chronic disorders such as cancer, arthritis, and respiratory disease are most prevalent in the highly developed and technologically advanced countries of the world. Diet, environmental contamination, and the increased levels of social stress associated with post-industrial societies are considered major factors in the development of these disorders.

A parallel can be drawn between this holistic health care movement and vision care. It is quite common for a patient to visit an optometrist because of poor visual acuity, and to have prescribed for him lenses which allow 20/20 acuity. It is also quite common, especially if this patient is a young myope, for him to return within a year only to have a stronger eyeglass prescription filled. Not enough vision care practitioners take the time to instruct patients on preventative vision care maintanence which can be incorporated into their daily routine.

An analogy is the patient who visits a medical practitioner because of continuing headaches. After a number of neurological tests are run with no clear etiological factor found, the treatment plan prescribed involves pain relieving drugs which deaden the sensitivity of the nervous system resulting in less pain. It is quite possible that these headaches are related to a stressful work or school environment, poor diet, a recent emotional event (ie. death, divorce), or the way this particular individual approaches his daily tasks. The patient could just as easily be a myope who was prescribed a full concave lens correction without thorough consideration of his daily environment. To many practitioners, the myopia which was measured is simply the result of an elongated eyeball secondary to normal growth patterns. It is also possible that the myopia measured is secondary to an adaptation by the visual system to a stressful nearpoint environment, poor nutrition, or simply the psychological approach that this particular person takes when interacting with his environment.

A number of vision care practitioners have incorporated holistic approaches when caring for the myopic patient. These treatment plans go beyond simply nuetralizing the refractive state of the eye and involve the patient becoming an active participant in his or her vision care program. Sherman,[153] as part of his overall treatment strategy, includes such environmental factors as posture, periodic rest periods while reading, daily exercise program, nutrition, advice on proper lighting and contrast during near tasks, and proper amounts of rest and sleep. Forrest[53] takes a psycho-behavioral approach to vision care, which "sees disturbances in physiological function as being a result of stress brought on by such factors as reading for meaning, working too close to the task, poor lighting, poor posture, poor seating and working conditions, viewing computer terminals, too many distractions, etc. There is greater recognition of the interplay between functions and an awareness that psychological and perceptual factors are involved."

As in the Holistic Etiology section, holistic therapy will be divided into three areas: stress reduction, psychological and emotional factors, and nutrition.

1. STRESS REDUCTION

A proper nearpoint prescription and vision therapy were discussed earlier in this paper as tools with which the vision care practitioner can lessen the degree of environmentally induced nearpoint stress. These two forms of optometric intervention are aimed at enhancing the visual system so that it does not succumb to the damaging effects of sustained nearpoint work. Within the holistic model of vision care, the patient can be an active participant in controlling his or her nearpoint environment by incorporating a number of visual hygiene guidelines into their daily routine. Guidance regarding proper visual hygiene to reduce intensity during nearpoint tasks and to control the nearpoint environment may serve to reduce nearpoint stress. According to Birnbaum,[146]"intense concentration is associated with increased muscular tension. Reducing such tension while reading fosters a more relaxed approach, with reduced sympathetic activation."

Nolan,[154] through the use of a myopia prevention booklet, has incorporated a number of visual hygiene techniques to create a successful myopia control program in his optometric practice. The booklet which is given to the parents of young potential myopes describes the myopic process and how steps can be taken to retard and even prevent myopic progression. Some of the techniques used by Nolan include: looking up at the end of each paragraph while reading, maintaining a maximum reading distance (knuckles to elbow *minimum*), desk placement (facing a window or open room), good posture, good illumination, applying all visual hygiene rules to any hobby which requires excessive nearpoint work, and TV glasses with a maximum-plus-at-10-feet prescription to relax any potential accommodative spasm. According to Nolan in the first year of implementing his myopia control program, only one patient out of 34 became myopic, and she was returned to hyperopia with some extra training.

Birnbaum[3] teaches proper visual hygiene as a part of his total myopia management program. Patients are counseled to work in a comfortable chair at a height which permits both feet to rest on the floor, to work at a desk which allows the reader a proper working distance, and to arrange lighting so that it is both adequate and glare-free. When reading, the patient is advised to hold the book at a 20 degree incline from the horizontal, so as to reduce muscular tension. According to Birnbaum[146], intense individuals often tend to pull reading material very close. The recommendation to maintain a longer working distance not only reduces the accommodative demand placed on the individual, but also serves to promote general relaxation and to reduce the intensity of application at near. The patient is also advised to assume a comfortable and relaxed posture when reading, to be aware of any muscular tension in the body and to relax, to breathe deeply, smile, and maintain a general awareness of the surround in order to create an attitude which promotes a more relaxed style of visual use.

Kaplan[71]utilizes various Bates techniques as a small part of his overall myopia management program. The basic theory behind these techniques is that eye muscle tension is found in the extraocular muscles rather than in the ciliary muscle or lens. The act of palming, sunning, and swinging in conjunction with various visualization activities serves to loosen the rigid position in which these extraocular muscles are held. Kaplan also emphasizes the importance of instructing patients on the importance of a regular and frequent blink rate. Nearpoint activities such as reading, doing fine detailed work, and looking at a computer screen can all lead to staring. The importance of a regular blink rate can be illustrated by the fact that the tears provide nutrients to the cornea, which controls

80% of the refractive power of the eye. The tear layer also provides a smooth, clear optical surface to promote clear transmission of optical light rays.

Posture is often mentioned as one aspect of proper visual hygiene. Darrell Boyd Harmon spent a number of years investigating the relationship between posture and vision. Harmon[155] stated that "vision is more than a higher-order skill, it is related to lower-order gravitational mechanisms and that an individual's visual space world is essentially an extension of the organization of the body's gravitational system." According to Kraskin[156] it has long been recognized that at least twenty percent of the retinal fibers lead to the posturing mechanisms of the body, rather than to the higher cortical centers, and that the key difference between the behavioral concept of vision and all others has to do with those 20% of retinal fibers leading to lower centers. Harmon felt that the work and illumination demands of our culture force people into persistent and prolonged postural skews which result in muscular tensions that eventually warp the individuals general posture. Harmon felt that it is warped posture that triggers most of the visual problems which are encountered in our society.

The relationship between visual function and posture was first noted by Lowman[157] and Mills[158] when they demonstrated that faulty posture could produce such visual conditions as esophoria, exophoria, hyperphorias, and anisometropias. They also showed that proper skeletal alignment tended to reduce the effects of these conditions. Harmon's research verified the findings of Lowman and Mills. His findings indicated that electrical or mechanical stimulation to the neck or back muscles can cause visual changes which are observable and can be measured with a retinoscope. Similar visual changes were observed by Harmon in those who exhibited poor posture, especially while engaged in nearpoint tasks.

Harmon noticed in his research that those subjects who were myopic often tended to incline their heads backward. He was of the opinion that the alignment of the vertical segments of the body related to refractive status, while the lateral segments of the body were related to phoria measurements. Harmon specifically associated a persistent shifting of the center of gravity forward, toward the center of the near task material, with myopia.

Bastien[63] prescribes lenses based on the postural response of the patient. According to Bastien "progressive high myopia, at its very beginning, is manifest as a behavioral response to the sustained near-centered reading and writing tasks of learning. This response is global and, as a global response, should be approached holistically. It implies the total mind and body considered as a unified action system under the control of the brain, it is the total organism responding as a whole."

Bastien introduced the term "reflex visuo-posture" (REVIP) to describe the reflex reading distance which is spontaneously assumed to perform nearpoint tasks. This REVIP is directly related to posture. According to Bastien the myope possesses a number of characteristic visual traits:

1. Pulls space in
2. Eso-centric spatial projection
3. Will change self in relation with space
4. Alters structures easily
5. "Short" REVIP

Bastien claims that when the REVIP is short, it will correlate with added postural tension in the musculature of the neck, of the shoulders, and of the back. A sustained tension in the trapezius, deltoids, and the dorsal muscles, which is prolonged over a long period of time, can result in an embedded postural muscular stress. This stress, according to Bastien, is caused by a postural over-centering of the body secondary to the short REVIP. Bastien believes that since myopes tend to alter structures easily and are more able to change self in relation to space, they seem to absorb the postural strain or stress by making morphological adaptations of their body posture.

Bastien[159] and Ludlam[160] use convex nearpoint lens prescriptions to elongate the habitual nearpoint working distance. According to Bastien, "any convex formula which elongates the REVIP is fully prescriptable, and is most likely to have a positive therapeutic effect. It should retard myopia if the patient is a progressive behavioral myope." Kraskin[51] believes that convex lenses act to reduce postural tonicity, while concave lenses tend to increase tonicity. According to Kraskin, "the use of minus lenses for near, when not required for standard acuity, results in increased myopia. Minus lenses increase the tonicity of the posturing muscles of the body. This increase results in a shifting of the center of gravity forward of the norm, hence, increased myopia."

For many progressive high myopes, Bastien will prescribe yoked prisms base down in combination with the convex nearpoint prescription. Although opinions on the subject of yoked prisms vary, they have been mentioned in the literature as having a profound effect on posture.[161,162,127] Bastien claims that yoked prisms base down have a widening effect on periphery, a height increasing para-convex effect, tend to improve posture, and reduce postural muscular tension. Press[127] summarizes the effect of yoked base down prisms as: moving visual space upward farther from one's center of gravity, eyes move upward, chin moves upward and outward, center of gravity shifts forward, pelvis shifts to tilt downward, and body moves forward on toes.

Kraskin[163] states that the posture of most myopes results in the center of gravity being shifted forward, which is reflected as a pelvic tilt upward. Kraskin, like Bastien, uses yoked prisms as a part of his overall myopia management plan. Unlike Bastien, Kraskin uses yoked prisms in a base up direction. According to Kraskin[164], the application of bases-up yoked prisms exaggerate the pelvic tilt upward and act to shift the center of gravity even further forward. He claims that if the system is free to do so, it will respond to this induced stress in the opposite direction. The organism would now show a reduction in postural stress, a reduction in pelvic tilt, and a shift of the center of gravity backward. The theory behind prescribing in this manner is explained by Kraskin as follows: "The yoked prisms that are used are those which are in the direction of the asymmetry, and thus, serve to exaggerate the assymmetry. They serve to induce a stress in the direction of the asymmetry and the system will respond to reduce the stress and, thus, alter the asymmetry in the desired direction."[165] When the counterstress behavior response has been made, the yoked prisms are removed from the lens prescription. According to Kraskin, the prism dioptrics of the yoked prisms should be less than that of which the patient is consciously aware of.

Introduction of general stress reduction procedures may be a useful part of an overall myopia management program. A daily exercise program, progressive relaxation techniques, meditation techniques, and instruction of proper diaphragmatic breathing may all be viable treatment considerations for the myopic patient who is subjected to a great deal of daily stress.

Exercise can play a crucial role in the fight against stress. At the end of a stressful workday, a persons entire physiology may be functioning as though their life is in danger. The fight or flight sympathetic response to stress is occurring, but the individual neither flees nor fights. According to Pelletier[49], this causes a prolonged level of unabated stress from which the individual has no respite. Movement serves to reduce activation of the sympathetic nervous system, therefore a regular exercise program may actually serve to reduce the build-up of chronic stress in our daily lives.

Progressive relaxation is based on the assumption that it is easier to learn to relax when one is more aware of tension.[146] Hewitt[166] states, "Muscle relaxation is the foundation of relaxed living, on which everything else may be built." The principle behind progressive relaxation is tensing a particular muscle group then letting go of the tension. When you let go of the tension, you are to dwell on the feeling of relaxation in the muscles. By following this procedure for muscle groups throughout the body, the patient learns to notice muscle tension when it occurs and is able to release it. Birnbaum[146] claims that when one is aware of tension and is able to release it, this awareness may be used to facilitate relaxation while performing near work. The beauty of this technique is its simplicity. Progressive relaxation teaches basic and essential relaxation skills and is easily accepted by patients without arousing negative feelings or associations.

Meditation has been practiced for many centuries as a way to reach a heightened level of conciousness. Today many people still associate meditation with eastern religion or with some form of mysticism. Scientific research in this country has shown that meditation acts to inhibit the sympathetic nervous system, resulting in a decrease in oxygen consumption and a decrease in systemic blood pressure.[166]

Meditation requires one to fix his attention firmly upon a given task for long periods of time. This concentration of one's attentional energy enables him to overcome the mind's usual habit of jumping from one thought to another. "When the incessant activity of the mind is stilled, the meditator experiences that aspect of his being which is prior to and distinct from his thoughts and from attention itself. It is this state which has been described as transcendental awareness, cosmic conciousness, or satori."[49]

Birnbaum believes that the physiological stress response is a product of inner verbalization and judgmental attitude towards a stressor object or event, as much as from the object or event itself. Inner verbalization, therefore, will tend to exacerbate the stress response. The daily practice of meditation will lead the patient to be more aware of this inner verbalization and allow him the ability to silence it, resulting in a less stressful physiological state.

Proper breathing habits have been mentioned as being vital to virtually all relaxation procedures. Breath is one of the few body functions that is both under voluntary and involuntary control[167], as such it can act as a bridge between our concious and unconcious functions. Deep diaphragmatic breathing may in itself be a useful means to reduce stress and generate relaxation. A simple technique used by Birnbaum, is to lie comfortably with eyes closed, inhale slowly and deeply so that the diaphragm expands and the abdomen rises. Then slowly exhale expelling as much stale air as possible, making room for fresh air on the next inhalation. As one becomes proficient with this breathing exercise, during the exhalation a relaxed state is reached in which tension throughout the body is released. This method also serves as a form of meditation. Since awareness is centered on the breath, distracting thoughts are gently pushed away.

Goodrich[55] claims that we restrict energy flow through our whole being by unconciously holding our breath. She believes that humans control their expression by controlling their breathing. Goodrich advocates the use of yawning to open the door to a more desirable fuller breathing pattern. According to Goodrich, facial muscles such as the masseter and temporalis become very tense and rigid with increased levels of stress. The jaw muscles tighten causing the teeth to grind inducing even more stress. When the masseter and temporalis are tight, the muscles around the mouth, in the cheeks and around the eyes also tighten up. Yawning will contract and relax these muscles together, bring fresh oxygen to all parts of the body including the eyes and brain, change emotional states from negative to positive, and can stimulate tear production that naturally bathes and moistens chronically dry eyes.

Once a patient learns to relax through the use of proper diaphragmatic breathing, this can be used succesfully to relieve some of the day to day tensions of life. Birnbaum has found that whenever one feels stressed , taking two or three deep breaths can often break the cycle of anxiety and provide immediate relief. This of course can be used as an adjunct to any visual hygiene program.

Stress reduction procedures can be a useful part of an overall myopia treatment plan. Procedures which utilize muscular relaxation, visual imagery, and peripheral awareness facilitate base-in fusion and accommodative relaxation. As a result, patients are less at risk to develop nearpoint stress-induced visual dysfunctions.[146] Stress reduction procedures also serve to reduce levels of physiological everyday stress, possibly reducing an individual's susceptibility to acquiring environmentally induced functional myopia.

Two individuals who manifest identical myopic refractive states may react quite differently to the same treatment approach. Certainly, when considering the treatment options available one cannot take a single factor approach to therapy. The same holds true when discussing holistic care treatment options. Although myopic progression may be controlled in one individual through the use of lenses and the control of the nearpoint environment, the same form of therapy may have little effect on the myopic progression of another individual. In light of this, other factors must be considered to explain this occurrence.

2. PSYCHOLOGICAL & EMOTIONAL FACTORS

A large body of literature exists associating personality traits with refractive state. Myopes are considered shy, introverted, socially awkward, and having tendencies toward overcontrol of emotions.[53,61] According to Hewitt,[166] personality type has a direct bearing on whether one reacts to stress with anger or with fear. He believes that anger is most commonly seen in extroverts while the fear or "flight" response is typically seen in introverts. When under stress the introvert becomes anxious, unsociable, depressed, and turns his thoughts inwards. On the other hand, the extrovert will become aggressive, excitable, restless, and turn his thoughts outwards.

Researchers have shown a link between illness and personality. Heart disease, cancer, rheumatoid arthritis, and migraine headaches have all been linked to certain personality types.[49] As researchers further define these behavior and personality types, it will probably become easier for practitioners to recognize these early psychological predispositions to disease. This of course will increase the chance of preventative intervention before the symptoms appear.

Forrest[53] has suggested that mental states are the primary factors which underlie functional vision disorders. Although vision problems may be triggered by environmental interaction, he believes that the fundamental causes are rooted in our attitudes and belief systems. Forrest has theorized that the specific visual adaptations which become manifest in each particular individual are actually a reflection of his or her mental state, attitude, beliefs, and information-processing style. Forrest believes that "stress comes from ones approach to a task and the often subconcious interpretations and judgements that act as a pre-set. This affects how one functions by inducing muscular rigidity that can persist even when the task is completed. The negative effects of stress all stem from the inability of the indivdual to flow with events rather than from physical or physiological stressor agents alone. The principal factors are those mental attitudes that are generated by deeply hidden feelings of inadequacy, vulnerability, helplessness, and the fear of change." A number of vision care practitioners address these psychological factors as a part of their myopia treatment plan.

Friedman[147] attempts to alter the myopic patient's viewing style by asking the patient to wear convex training lenses instead of concave corrective lenses, whenever feasible to do so. While wearing these training glasses, an intentional blur is induced requiring the myope to adopt a different viewing style. According to Friedman the desired effect is to have the patient, in a sense, "give up" visually and resist attempts to clear blurred vision. While wearing the training glasses, the patient is told to take a passive or "defensive" viewing style as opposed to the more natural "offensive" visual style which is characterized by intense information collection. The patient is also advised to view the entire visual field rather than concentrate on the details of a single object.

Birnbaum[168] has observed changes in personality following a vision therapy program. He has proposed that these psychological changes may occur as a result of (1) frequent elicitation of the relaxation response during vision training activities which emphasize peripheral awareness, and (2) a reduction in sympathetic nervous system activity which comes about through a reduction in visual stress.

Kelley[54], from clinical observation, described refractive condition in Reichian body energy concepts. He feels that the myope shows an energy flow inward, contractive, toward self, while hyperopia causes the reverse, i.e., outward, expansive, away from self. Because of this inward energy flow Kelley believes that the myope actively blocks his feelings of fear, building layers of emotional and psychological armor. The release of these blocked emotions not only is said to improve vision, but also to produce changes in the entire organism i.e. posture, muscular tension, and state of mind.

The freeing and discharge of feeling is the ground on which the Kelley vision improvement work takes place. Kelley believes that by freeing emotions and feelings which have been blocked for many years, the patient becomes more accessible to specific vision improvement techniques. The vision techniques used by Kelley include Bates[169] vision improvement drills and Renshaw[145] tachistoscopic training. Other forms of therapy used by Kelley include Neo-Reichian emotional release work[170] to free blocked feelings which affect vision and Lowen stress positions[171] and other bioenergetic drills to mobilize the body's energy.

Grossman[172], drawing heavily from the work of Elliot Forrest and Ann Nichols, takes a more optometric approach to dealing with psychological factors involved in myopia. He believes that the patient's visual condition is representative of that individual's own unique expression of himself. The following are some of the foundations on which he views vision in this manner:

1. Vision is in many ways a reflection of mental life.
2. Visual conditions are an expression of mental life.
3. One role of behavioral vision care is to help individuals become more aware of how their beliefs, attitudes, and perception of life and oneself affect their vision in stressful ways.
4. Vision can be used as a reference point for biofeedback.

Grossman believes that individuals respond differently to visual stress depending upon their own distinct personality make-up. As an individual develops and begins to interact with their environment they are molded by their physical and emotional surrounds. These experiences help the patient to form beliefs and attitudes which often remain with them throughout their life. Because of these differences Grossman, drawing from Nichols, classifies two types of myopia: (1) the feeling myope, and (2) the analytic myope.

When discussing the feeling myope, the myopia is in the total organism. He is not seeing outside himself, but inside himself. Typical visual findings are: low positive relative convergence at near, high minus on PRA (visual space comes toward patient), and typically an exophoric posture at near. Characteristics of the feeling myope include: 1) feels helpless, 2) views world as being unsupportive, 3) appears weak and needy, wants others to help them, 4) doesn't hide feelings, 5) is more interested in how you say something than in what you say, 6) functions primarily at an emotional "feeling" level, and 7) is easy to trust. The general posture is slumping downward, looking dependent, and having weak muscles. They tend to be undercontrolled by the concious mind.

An approach in therapy for the feeling myope should be to give support, nourish, offer warmth and comfort. This type of individual needs to practice trust in themselves in relation to vision, therefore techniques which use feedback that their eyes are doing what their concious mind tells them are quite helpful. Examples of these types of techniques include vectograms and brock string. Another goal of therapy should be to get the patient to trust his visual environment, therefore lots of movement and localizing tasks will be beneficial. Grossman also encourages the feeling myope to do more physical activity such as running, swimming, dancing, and martial arts.

The other type of myope is the analytic myope. Typical visual findings include: high positive relative convergence at near, high plus on NRA, an esophoric posture at near, and a tendency to show a SOLI response on vectograms. The analytic myope is typically a very logical person who has a real need to be accurate and precise in all that he does. He typically thinks more than he sees, dissociates thinking from feeling, is overfocused and tends to analyze everything. The analytic myope is generally a perfectionist who has a number of underlying fears, since he never really enters the world of feelings. Other general characteristics listed by Grossman include; 1) not in touch with their body, 2) avoid closeness, and 3) are very suspicious of therapy, yet really want to do it. The analytic myope tends to be overcontrolled by the concious mind. His posture tends to hold a lot of tension in the chest and upper back as well as in the occipital region.

Some therapy approaches recommended by Grossman for the analytic myope include: 1) focusing on meeting the person where they are, 2) go slow, making sure that the patient knows WHY and WHAT and HOW they are doing each technique, 3) slowly try to introduce identification with feeling tones in body and then in vision, and 4) incorporate gross motor work with visual targets i.e., balance beam while reading letters to a metronome.

The role which personality and emotions play in myopia is still not clearly understood. It would be shortsighted to totally dismiss this area as not being a factor in the development of refractive states. Aldous Huxley[173] summarized the inter-relation between psychology and vision:

"That a function so intimately related to our psychological life as vision should remain unaffected by tensions having their origin in the conscious "I" is inconceivable."

Many people today are discovering the power that they possess within. Changes in lifestyle and attitude are being used by many medical professions as a means to curb heart disease. Visualization and imagery are becoming widely accepted as viable therapy for cancer patients. If in fact a change in one's attitude and personality can bring about changes in general health, why is it so inconceivable that these changes may be seen in the visual system as well? Dr. Kenneth Pelletier offers sound advice that we as health care providers should all consider. He states:

"the practitioner must come to know himself as a human being. Anyone in a healing profession must become acquainted with his own emotional nature, his personality conflicts, his strengths and weaknesses, and generally to engage in a process of self-exploration...It is hoped that the practice of preventative medicine which focuses on the entire person (body, mind, spirit) will also help practitioners themselves become more fulfilled in their lives."

3. NUTRITIONAL FACTORS

For many years there has been an interest among vision researchers regarding the relationship of nutrition to myopia. Lane[67] stresses that myopia prevention requires the adequate ingestion and absorption of nutrients that aid in the maintenance of normal intraocular pressure levels and that build scleral collagen strength so the sclera can resist distension. Lane singles out three deficit-inducing diets which he feels are associated with the development of myopia: (1) excessive consumption of refined carbohydrates in too high a ratio relative to complex carbohydrates, (2) excessive consumption of denatured flesh protein, and (3) inadequate intake of dietary fiber and folate.

Bell[23] has stated that the effects of vitamin C on scleral tissue should be closely studied, since it seems to have an effect on many other forms of connective tissue throughout the body. He believes that vitamin C could be an important component in reducing myopic progression, since it has been found to increase the tensile strength of connective tissue, as well as reduce I.O.P.

Rotte & Yamamoto[174] have reported on the Yoga outlook on food which is based on observance of the principles of natural law with consideration for individual needs. According to this dietary plan, the best foods for a human being are those which can be eaten whole. The reasoning behind eating whole foods, including whole grains and the roots plus the leaves of vegetables, as well as food from the sea, is that it enables the blood to maintain a normal acid / alkaline balance. Other guidelines for following natural law regarding food are to eat only what is capable of growing within one's climatic zone, and to eat only foods that are in season. By honoring these, the body is better able to harmonize with nature. It is the view of Rotte and Yamamoto that since healthy eyes require plenty of oxygen plus vitamins and minerals, nutritionally unbalanced people are more likely to become nearsighted.

A number of vision care practitioners have reported on the use of nutritional counsel as a part of an overall myopia management program. Sherman[153] advises myopic patients to restrict all "junk" foods. Kaplan[71] through personal and clinical experience has suggested that one can clearly monitor his degree of vision efficiency by the type of food that he eats. Foods and substances which Kaplan advises his patients to refrain from include: alcoholic beverages, caffeine, canned foods, cheese, cigarettes, coffee, nonprescription drugs, eggs, fried foods, fruit, ice cream, milk, red meat, and sugared items. A nutritional guideline proposed by Kaplan includes the following:

1. One salad per day
2. Raw/steamed/lightly cooked vegetables every day
3. Herb or bancha tea
4. Fasting for one day
5. Seasoning as recommended in macrobiotic cookbooks
6. One serving of fish or poultry every other day instead of red meat
7. Tofu (bean curd), mochi (sweet rice), and tempeh (from soybean)
8. Grains such as short grain brown rice, millet, quinoi, kasha, and basmati rice
9. Root vegetables and squashes
10. Natural multivitamin and mineral supplements

Kappel[175] takes a bit more conventional approach to incorporating nutrition into an optometric practice. He believes that vitamin deficiencies can create a number of severe consequences, many of which are visual. According to Kappel, a vitamin deficiency may occur in a number of ways, the most obvious is not eating the proper foods or eating foods lacking in nutritive substances. Foods can lose many of their vital nutrients due to improper cooking procedures or exposure of the food to air and to sunlight. Our bodies also lose nutrients in an effort to fight toxins ingested or respired such as: smoke, coffee, sugar, refined flour, preservatives, artificial flavors, artificial colors, and drugs. Kappel also singles out stress as being a major source of using up important nutrients in very large quantities. This of course has important implications when tied to the nearpoint stress theories of Skeffington and Birnbaum.

Kappel[70] has investigated the effects of nutrition as they pertain to myopia. He lists a number of factors which he feels should be considered in understanding myopia and its control or elimination. Kappel lists (1) tissue strength and tone, (2) tissue clarity, (3) nerve function, (4) circulation, and (5) stress. Appropriate vitamins and minerals for each specific factor are listed. Kappel has claimed that "by controlling these factors, much can be done nutritionally to control, prevent, and even reverse myopia, when combined with optometric care, i.e., proper lenses for near seeing, optometric visual training when indicated, and attention to proper posture, illumination, exercise, and rest."

The secret of nutrition control, according to Kappel, lies not in one ingredient but in the proper balance of all the food ingredients. Vitamins, minerals, protein, fats, fiber, and glandular support raw concentrates, all organized together to produce healthy tissue, cells, and function.

Holistic aspects of vision care, such as those listed in this section, are often ignored in the optometric profession. Allowing patients to assume some responsibility for their visual status may be frightening to many practitioners. As our profession moves into the 21st century, serious investigation of methods which help prevent, control and even eliminate refractive problems is needed. The use of various stress reduction techniques, psychological approaches, and nutritional counsel may be beneficial in treating the whole person rather than just one symptom (distance blur). Two important factors of holistic vision care need to be emphasized:

1) treating each individual as being unique instead of diagnosing a visual condition, and treating all patients with that condition in the same manner.
2) People do not have to have a visual condition in order to involve themselves in holistic vision care. Patients are encouraged to become aware of the possible stresses, both internal and environmental, that could predispose them to a visual condition such as myopia.

Chapter 16.
BIOFEEDBACK / VISUAL ACUITY TRAINING

It has been proposed that accommodative biofeedback training may be useful in producing a reduction in myopic refractive conditions, along with an improvement in unaided visual acuity.[176] These changes are said to occur by training subjects to control their accommodation voluntarily.[177] Biofeedback has been defined as the control and awareness of a bodily function or process of which a person would not normally be aware.[176]

Trachtman has developed a method of using biofeedback training to improve visual acuity in myopic patients. The device used, an "Accommotrac," is an infrared optometer which measures accommodation every 32 milliseconds. The accommodative stimulus is a small monochromatic fixation target which can be presented at different dioptric settings. The training is done in the dark, and an auditory feedback device is used. The tone generator connected to the optometer produces a change in pitch when accommodation is varied.

Trachtman has reported an average reduction in myopia of 3 D for 15 sessions and 2.75 D for 8 sessions. According to Trachtman, the reduction in myopia is due to a reduction in parasympathetic muscle tone and an increase in sympathetic muscle tone. Trachtman attributes about 2 D of myopia reduction to a relaxation of ciliary spasm, and the remainder of reduction which occurs is due to a change in the tone of the "sympathetic component of the ciliary muscle."[178]

Berman[179] designed a study to replicate Trachtman's findings. Results of the study supported Trachtman's claim that biofeedback visual training is an effective method for improving visual acuity. The study also indicated that visual gain can be predicted fairly accurately and will vary as a function of pre-training visual acuity.

Gallaway et. al.[180] performed biofeedback training of accommodation with nine subjects using the Accommotrac Vision Trainer in an attempt to improve visual acuity and reduce myopia. An improvement in visual acuity was seen with some subjects, but it was unclear to the investigators whether the improvements were due to the biofeedback training or to a learning effect observed during repeated measurements of VA. The results of the study suggest that biofeedback training with the Accommotrac may have yielded improved VA in several subjects, but the improvement was not accompanied by a change in refractive condition. Trachtman's claim of 2 D to 3 D of myopia reduction was not substantiated in the Gallaway study. Gallaway et. al. have made a call for furthur research in this area to determine the clinical usefulness of biofeedback training of accommodation as a means of myopia reduction and VA enhancement.

Much attention has been given to the topic of behavioral visual acuity training in psychology. Psychology studies support the viewpoint that there is a definite behavioral component to myopia. Lanyon and Giddings[61] have described myopia as a behavioral-physiological process which is reversable to some extent. Many of the psychologically-based behavioral vision acuity training programs are derived from the original work of William Bates[169]

Epstein et. al.[181] have developed a visual acuity modification program using a technique very similar to the optometric procedure of "Hart Chart Walk-Away." The procedure involves the patient learning to identify letters on a distant chart while progressively increasing the distance between the patient and the chart. The term used by the psychology researchers for this type of procedure is "fading." Another factor added to the procedure, "feedback," was positive verbal reinforcement for correct answers given by the subject. Collins et. al.[182] conducted a study to determine which of these two factors was the predominant source of the observed acuity improvement in behavioral training. The results suggested that fading, not feedback, is the critical component of visual acuity training.

Improved acuity with behavioral training is often dismissed as being due to a learned skill of retinal blur interpretation. Collins et. al.[183] cite three studies[184,185,186] as evidence that the mechanism for improvement is a physiological change in the optical system of the eye rather than a learned skill of blur interpretation. Balliet et. al.[187] attribute the success of their visual acuity training, with a computerized optometer, to "the formation of an artificial contact lens resulting from tear film changes."

It should be noted that many of the studies which claim to be successful in improving visual acuity do not show an associated improvement in refractive condition.[187,188,189] A recent study by Pbert et. al.[190] investigated the relationship between visual acuity improvement and refractive error. The results indicated significant increases in recognition visual acuity with feeding and feedback behavioral training. The trained subjects, however, showed no improvement in refractive condition. The authors concluded from the data that the visual acuity improvements typically found with behavioral training are not associated with changes in refractive condition.

Collins et. al.[191] investigated the long-term effects of behavioral visual acuity training. Subjects were trained for 12 days following a three-day baseline measurement period. Acuity testing was done weekly for nine weeks after the conclusion of training.

The results of the study showed that the improved acuity was maintained throughout the nine week follow-up period.

Graham and Leibowitz[192] claim that the improved visual acuity obtained through the presentation of direct hypnotic and post-hypnotic suggestion "parallels the results obtained through longer and more complicated optometric training procedures, suggesting perhaps that the myopic individual sets his internal standard of daily visual performance lower than necessary. Through failure to see distant objects as clearly as desired he may become progressively more dependent upon the corrective lenses and no longer try to exceed the internal standard, except under unusual circumstances."

Furthur scientific research in the areas of biofeedback and visual acuity training is needed to evaluate the effectiveness of using such procedures in a clinical setting. If the results reported in the behavioral psychology studies are reliable, visual acuity training may be a useful adjunct to a myopia control or myopia reduction program. These procedures would have significant implications for those patients needing to improve their performance on visual acuity tests for vocational reasons.

PART FOUR

AN INTEGRATIVE TREATMENT MODEL

Chapter 17.
AN INTEGRATIVE APPROACH TO TREATMENT

As seen in the previous three sections of this paper, there are many schools of thought concerning the etiology and treatment of myopia. How one views the etiology, and therefore treatment, of myopia is dependent on the clinician's personal experience, education, and model of vision. Advocates of the various treatment modalities all claim their method as being successful. If one were to consider, without any personal bias, the possibility of integrating treatment options from various schools of thought, it is possible that strides could be made in the clinical management of this all too common visual condition.

A number of factors must be considered when treating the myopic patient. The clinician should carefully consider the patient's age, genetic disposition, initial refractive condition, visual environment, motivation level, and personal goals. With this information at hand, the clinician is better able to address the needs of his or her patient and present pertinent treatment options on an individual basis instead of treating all myopic patients with only one treatment strategy.

Studies have shown that the majority of myopia cases begin during the school years, with clusters of beginning myopes found at ages 8-10, 13-15, and 18-21.[41] These age groups seem to correlate with shifts in nearpoint demands placed upon the individual. Age 8-10 is the period where children typically begin to "read to learn" instead of "learn to read." Ages 13-15 mark the beginning of junior high school and an increased emphasis on independent study along with an increased volume of reading. Ages 18-21 mark the period of time when one enters college or begins an occupation with higher levels of nearpoint demands. In light of this information, the clinician must carefully consider the age of the patient before a therapy plan is decided upon. An eight year old .50 D myope is certainly not the same as a 28 year old .50 D myope, and so each should be approached in a different manner.

Although no genetic strain has been isolated which may cause myopia, it has been shown that a strong genetic correlation does exist.[14] A possible clinical implication would be a non-myopic child whose parents are both highly myopic. Because of the increased chance of this child becoming myopic, preventative treatment options may be indicated.

Another consideration is the refractive condition of the patient upon presenting to your office. The type of treatment which would be indicated is very much dependent on whether the patient has a low, moderate, or high amount of myopia. Kraskin[149] has found, from clinical experience, that the myope who has never had compensatory lenses for distance viewing has a much better prognosis for improvement than the myope who has compensatory lenses and uses them constantly for distance and near viewing.

The patient's visual environment must be considered before deciding on a treatment plan. A 2.00 D myopic construction worker who doesn't enjoy reading would not be treated in the same manner as a 2.00 D myopic office worker who spends 8 hours per day looking at a computer monitor. Other environmental factors besides amount of near work include; type of near work, lighting conditions, working distance, posture, and design of the workspace.

When interviewing the myopia patient, an evaluation should be made of the individual's motivational level. Alternatives of optometric care should be presented to the patient. If the individual is not motivated to control or improve his eyesight, he may choose the most basic form of myopia therapy, the prescription of compensatory concave lenses for full-time distance and selective nearpoint use. Patients with higher levels of motivation will want to participate in a myopia control program. Such a program may consist of a number of methods aimed at halting the progression of, or even reducing, the patients myopic refractive condition. It should be mentioned that a myopia reduction program requires a significant commitment by the patient and therefore only the most motivated of individuals should be accepted for this type of myopia care. By providing the patient with alternative levels of vision care, you are letting the patient choose the type of vision care which best fits his own personal situation. Instead of dictating one mode of therapy to the patient you have now given him a choice. A patient who feels as though he has played an active role in determining his own course of treatment will most likely be more motivated to succeed.

The final factor to consider before deciding upon a treatment option is the personal goals of the patient. Patient goals may include the prevention of myopia, compensatory lenses which provide 20/20 acuity at distance and near, the control of myopic progression, or even the elimination or reduction of a myopic refractive condition. The list of possible patient goals is endless, adding even more weight to the notion that each patient should be treated on an individual basis. For the sake of simplicity, I have separated treatment goals into three distinct catagories; (1) prevention, (2) control, and (3) reduction. In the next three chapters a hierarchical model of myopia management options for each of these three treatment areas, based on the previous literature review, will be discussed. Descriptions of various techniques can be found in the appendices. The treatment plans proposed are an integration of a number of procedures and techniques available to optometry. It is our duty as vision care professionals to be aware of and be able to use all of the tools with which we are licensed to treat myopia.

Chapter 18.
MYOPIA PREVENTION

It has been stated that prevention is the highest form of health care.[93] Pelletier[49] has commented on the fact that most of the research and clinical emphasis in the field of health care is on the correction of existing pathology rather than on its prevention. As preventative health care continues to gain acceptance, vision care practitioners should consider including preventative vision care measures as a part of their overall treatment program. Although preventative vision care has not been the highest priority in the optometric or ophthalmologic professions, various methods have been used by vision care practitioners to aid in the prevention of myopia. In this chapter preventative treatment options will be discussed, along with the proposal of a hierarchical myopia prevention plan.

In a recent study, Goss[91] found that a greater amount of myopia at the initial examination age was associated with a greater rate of myopia progression. In light of this information, preventative intervention often needs to begin before a child enters the nearpoint-intensive school environment. Because children are generally hyperopic before entering school, this is the time when preventative care may be most beneficial. Birnbaum[3] states, "The competent, concerned clinician should be on the lookout for early signs of myopia, for it is in the earliest stages that preventive care is most efficacious." If a genetic predisposition to myopia exists, an early vision evaluation is vital. Supplemental literature should be available to patients concerning available approaches to myopia prevention so that an intelligent choice concerning the course of treatment to be followed can be made.

Subjective warning signs associated with early myopia include a tendency to hold reading material closer than Harmon's distance, nearpoint asthenopia, distance blur after sustained periods of near work, and difficulty changing focus distance quickly. Objective clinical signs of early myopia include esophoria (or reduced exophoria at near), slightly decreased distance acuity, poor performance on accommodative facility testing, low negative relative accommodation, and the positive relative accommodation finding adequate or in some cases low. If these signs and symptoms are discovered early on, the chance of success using various preventative treatment measures will improve. Early preventative vision examinations, especially for those with a genetic predisposition to myopia, are vital to a preventative myopia treatment program. This preventative vision care approach should not be limited to young children. With the increased use of personal computers and nearpoint work in our society, many adults are at risk for these early signs and symptoms of myopia.

The prescription of a nearpoint lens, if indicated from the analytical exam, may be another effective myopia prevention technique. A properly prescribed nearpoint lens prescription acts to reduce the amount of accommodative demand and associated overconvergence, allowing increased levels of comfort and efficiency at near. The prescription of an arbitrary nearpoint lens may actually increase the chance of myopic progression. An individualized analytical evaluation should be performed for every patient. There are a number of methods to determine the appropriate amount of plus lens power to be prescribed at near. It is beyond the scope of this paper to describe the various methods but examples include the fused cross cylinder finding, balancing the PRA and NRA, dynamic retinoscopy (eg. MEM, Bell, Book, and Stresspoint), effect on the near phoria, the patient's subjective response to the lenses, and the patient's postural response to the lenses. Most methods of nearpoint analysis, such as OEP case analysis, rely on a combination of many of these findings to arrive at a proper lens prescription.

For preventative treatment, the farpoint acuity will often be standard, therefore single vision nearpoint lenses for all nearpoint work may be the spectacle of choice. Ludlam[160] advocates the single vision lens with a strap so that when viewing the chalkboard the spectacles can be worn around the neck. Bifocals may also be indicated for preventative purposes. Because it is inconvenient for the child to continually remove and replace the spectacles in the classroom, a bifocal lens can be prescribed for constant wear in school. Birnbaum advocates the use of a bifocal prescription and believes that it is unlikely that single-vision reading glasses will be used properly by school children. If cosmesis is an issue when deciding upon a nearpoint lens prescription, a blended (seamless) bifocal will provide a bifocal lens without the noticeable bifocal line.

Vision therapy may be used in a myopia prevention program to improve overall visual efficiency and increase the patient's amount of plus lens acceptance at near. By increasing the effectiveness of the visual system through the use of vision therapy, the patient can better withstand the visual stress associated with sustained nearpoint tasks.

Very early myopia is often characterized by signs of accommodative problems. Therapy which emphasizes the stimulation and relaxation of the accommodative system, such as accommodative rock techniques, are helpful. This type of therapy increases the patient's ability to focus from distant to near objects easily and effectively. Voluntary accommodative relaxation procedures to increase the level of plus lens acceptance is also helpful in preventing myopia.

Esophoria, or overconvergence, is another early sign of nearpoint stress leading to a myopia adaptation. Vergence therapy to place the accommodative and vergence systems in balance is helpful in preventing early myopic changes. Procedures such as fusion range extension, BOP-BIM techniques which improve the flexibility of the accommodative-convergence linkage, and voluntary vergence control techniques are indicated for a myopia prevention program.

Advice concerning visual hygiene is a vital part of any preventative vision care program, especially in the case of myopia. Nearpoint asthenopia and accommodative hysteresis may be greatly reduced through such simple procedures as increasing ones working distance to reduce accommodative demand, the use of good lighting, good posture, taking periodic breaks from sustained nearpoint visual tasks, and maintaining an awareness of the surrounding environment while reading in order to foster a more relaxed style of nearpoint concentration. These are procedures which can be adopted at an early age with the goal of developing proper lifelong visual habits.

Stress reduction techniques can be incorporated in a prevention program, especially for adults who are exposed to a daily nearpoint environment. Instruction on methods to relieve stress, such as a daily exercise program of some kind, proper breathing habits, meditation, imagery, and progressive relaxation may decrease overall levels of anxiety and stress, thereby making the individual less susceptable to visual nearpoint stress.

Nutritional counsel may be a helpful adjunct to any myopia prevention program. Advice regarding the adequate intake of essential vitamins and minerals along with reducing the consumption of such foods as sugar, caffeine, tobacco, preserved foods, refined carbohydrates, and red meat is helpful in promoting proper development as well as an overall sense of well-being.

The following are guidelines for developing a myopia prevention program which can be used in a clinical setting:

MYOPIA PREVENTION:

1. Myopia prevention must begin early in life and include regular preventative vision examinations.
2. A preventative nearpoint lens prescription, if indicated by the analytical exam or other testing, is an effective tool to delay or eliminate a myopic visual condition.
3. Preventative vision therapy will increase the efficiency of the visual system in order to withstand the visual stress caused by sustained nearpoint tasks.
4. A visual hygiene information booklet or videotape distributed to all patients, with instruction on the proper use of the visual system, will allow patients the ability to decrease the level of nearpoint stress to which they are subjected.

5. Advise patients on such stress reduction techniques as a daily exercise program, proper diaphragmatic breathing, meditation, and progressive relaxation to decrease the level of overall stress, thereby decreasing the susceptibility to nearpoint visual stress.
6. Nutritional counsel to promote proper development of body tissues and a sense of well-being may be a useful adjunct to a preventative myopia control program.

Chapter 19.
MYOPIA CONTROL

The patient who presents to your office with an already myopic refractive condition is a candidate for myopia control therapy. Important factors which need to be considered when deciding upon a myopia control treatment plan are the patient's age and the patient's personal goals. An already myopic child who has many years of school remaining can benefit immensely from a myopia control therapy program. The goal of such a program is to slow or possibly halt the progression of myopia. A patient who expresses concern about the continual advancement of his myopic condition will likely be motivated to take part in a treatment program designed to slow myopia progression.

Many of the methods used to prevent myopia are also used to control it. The added factor which now must be considered is the presence of decreased distance acuity. Kraskin[149] has described three catagories of myopes. The first category is the myope who has never worn compensatory lenses for distant viewing. This is the patient with the best prognosis not only for control, but also for elimination of the myopia. The second category is the myope who wears compensatory lenses, but only for selective distance viewing. This patient has a good prognosis for control and possible elimination of myopia. The third category of myopia is the patient who wears compensatory lenses constantly for distance and possibly even at near. The prognosis for improvement with this patient is poor but intervention aimed at controlling progression will be beneficial in most cases.

A lens prescription needs to be provided for the myopic patient. Lens power greater than what is required for normal daily viewing conditions should never be prescribed. The distance lens prescription will vary with each individual patient, but the binocular maximum plus to 20/20 finding is an excellent guideline. Kaplan[71] and Sherman[153] recommend an undercorrection for distance viewing. Both authors advocate "peeling" off minus lenses to 20/40 acuity. When confronted with this small amount of blur, the myope is able to use his own visual system as a biofeedback source. While taking part in various treatment strategies the patient is able to monitor an improvement in visual acuity. If the patient is corrected to 20/20 or even 20/15 it is difficult to notice improvements which may occur with treatment. If undercorrection distance spectacles are prescribed, "20/20" driving glasses should be considered as well.

If a full minus compensatory lens is prescibed, it is vital to perform a nearpoint analysis. Studies have shown bifocals to reduce the progression rate of myopia. If indicated from the analytical examination, a nearpoint lens should be strongly considered. This is generally best prescribed in bifocal form. Some school children may be apprehensive about wearing bifocals. If the advantages of a nearpoint lens are properly explained the apprehension may disappear. A round or kryptok bifocal may be prescribed to reduce the visibility of the bifocal segment. Although slightly more expensive, the blended (seamless) bifocal provides excellent cosmesis.

Vision therapy is a useful adjunct to a myopia control treatment program. Patients with low amounts of myopia benefit the most from a vision therapy program. High progressive myopes can benefit as well by improving the efficiency of the visual system in order to withstand the visual demands of nearpoint tasks. Vision therapy similar to that used for prevention is indicated in a myopia control program. Some additional methods which may prove to be beneficial include intensive BI training to reduce the tendency towards overconvergence and to elicite an associated negative accommodation response, techniques which teach the voluntary control of accommodation so that the ability to maximally inhibit the accommodative system is learned, and the use of peripheral awareness training to elicit a more relaxed or passive viewing style. For a listing of various myopia control vision therapy techniques see appendix A.

Proper visual hygiene is helpful in controlling the visual environment of the myope. The patient who avoids situations likely to provoke a nearpoint stress response such as reading poor quality print, inadequate illumination, sustained nearpoint activity without breaks, etc. is less likely to show progressive myopia changes over time. Visual hygiene counsel such as that described in the "prevention" section is indicated as a useful method in controlling myopic progression. For a listing of various visual hygiene guidelines see appendix B.

Holistic modes of therapy helpful in controlling myopia include general stress reduction & relaxation procedures, daily exercise, addressing any psychological or emotional factors which may exist, and nutritional counsel. The myope who is intense and highly analytical will typically approach nearpoint tasks with high levels of attentional energy resulting in increased levels of visual stress as well as general tension and stress. Advice and instruction on general stress reduction techniques may be quite beneficial and certainly worthwhile. A daily exercise program such as running, dancing, playing basketball, raquetball, tennis, etc. provides an outlet for the internal stress so common in our society. The improved sense of healthfulness and well-being which often occurs through the use of such techniques may improve one's outlook on life in general.

Psychological and emotional factors have been linked to myopia. Addressing these issues is not easy for most optometric clinicians. Kaplan[71] has proposed that an individual's level of "visual fitness" may stem from events in the past that triggered fearful or limiting eye and mind perceptions. He believes that the reason some individuals cannot see as well as they should is simply fear and suppressed anger. If the optometrist suspects a psychological problem associated with the decreased acuity, proper referral to a mental health practitioner is advised. Vision therapy has been shown to cause personality and attitude changes in some individuals, and so may be helpful as well.

The use of rigid contact lenses has been shown to reduce the progression rate of myopia in some individuals. The clinician needs to assess the motivation and maturity of any patient to be fit with contact lenses. If contact lenses are prescribed, a nearpoint lens prescription to be worn for all nearpoint tasks is recommended. Orthokeratology, although often thought of as a myopia reduction method, may also be used to halt the progression of myopia. The use of "ortho K" lenses has been shown to generate a change in refractive state which is opposite to that seen with myopia progression.

Visual acuity and accommodative biofeedback training are methods which have been shown to improve visual acuity. Accommodative biofeedback training has also been reported to cause a slight reduction of the measureable refractive condition. If the clinician is to halt the progression of myopia, techniques such as these may be helpful in delaying the typical progressive changes seen especially throughout the school age years.

Nutritional counsel such as that discussed in the "prevention" chapter should not be overlooked as a viable part of a myopia control program.

The following are guidelines for a myopia control treatment program:

MYOPIA CONTROL:

1. Goal is to slow and possibly halt the progression of myopia.
2. Never prescribe compensatory distance viewing lenses which have lens power greater than that required for normal daily viewing. A maximum plus to 20/20 or even 20/25 is recommended.
3. A maintanence nearpoint lens prescription, if indicated by nearpoint analysis or other testing, is helpful in controlling the progression of existing myopia. Bifocals are recommended for patients with already reduced distance acuity.
4. A vision therapy program with emphasis on BI vergence training, voluntary accommodative training, and peripheral awareness training may be helpful in curbing the progression of myopia.
5. Accommodative biofeedback and visual acuity training may prove useful in negating the effects of nearpoint visual stress on myopic progression.
6. Proper visual hygiene may be helpful in slowing myopic progression

7. Holistic modes of therapy such as general stress reduction techniques, progressive relaxation, a daily exercise program, addressing psychological factors, and nutritional counsel may help control myopic progression.

Chapter 20.
MYOPIA REDUCTION

There is a wealth of literature which proposes that an individual can improve his vision through the use of various techniques or exercises. A large part of this literature is based, at least in part, on the work of Dr. William Bates.[169] Gottlieb,[193] in an effort to establish the credibility of Bates and to reexamine his ideas with reference to modern neurological concepts, developed a model which combines the work of Bates with that of Karl Pribram.[194] In his dissertation, Gottlieb concludes that "Bates' ideas should be given serious consideration by optometrists, vision scientists, and other professionals; myopia is more flexible than is generally conceived; and it is important to develop a new paradigm of visual care which examines the more subtle implications of the nearsighted response and the possibilities of prevention and remediation."

Individuals who express an interest in improving their eyesight, should be made aware of the various techniques, both optometric & non-optometric, which have been reported in the literature. A number of methods exist to reduce or eliminate refractive problems. Optometric methods include orthokeratology, visual acuity training, accommodative training, vision therapy, and the use of lenses. Ophthalmological methods include refractive surgeries such as radial keratotomy, keratomileusis, epikeratoplasty, keratokyphosis, and, recently, excimer laser corneal surgery. Other approaches include the use of psychological therapy, various body therapies, acupuncture, and color or light therapy.

Optometrists are often confronted with a patient who needs to improve his eyesight for occupational or vocational reasons. Many occupations have stringent visual acuity requirements. There are also individuals who are very health conscious and would be interested in a myopia reduction program. To reduce one's refractive condition requires high levels of motivation and changes in one's beliefs, attitudes, and lifestyle. These are all mental states which have been conditioned throughout the individual's lifetime, therefore change may occur slowly. This chapter will suggest various methods which may prove helpful in reducing myopic refractive conditions. A more complete listing of myopia reduction techniques is presented in the appendices.

The first factor which needs to be addressed when conducting a myopia reduction program is the lens prescription. An undercorrection at distance is helpful in allowing the patient to monitor his level of visual acuity. By "peeling off" lens power to 20/40 acuity, the patient is able to directly observe the effects of their internal and external environment upon their visual acuity. Through various myopia reduction techniques the patient can now work towards improving that 20/40 acuity to 20/20. The goal of this type of lens prescription is that when the patient notices a decrease in visual acuity he will be able to use visual skills learned through the various vision improvement methods (which are being learned concurrently) to take action and counter the decreased level of acuity. By incorporating these newly learned vision skills, as well as making lifestyle changes such as diet, exercise, and attitude one may be able to stabilize his visual acuity at 20/20 through the 20/40 lenses.

A nearpoint lens prescription, if indicated from the analytical nearpoint analysis or other testing, is also an important part of any myopia reduction program. The nearpoint lens may be useful in negating the reduction of distance acuity caused by nearpoint visual stress. Patients should be advised to wear these spectacles as much as possible to help foster a more passive relaxed viewing style.

Vision therapy is an important piece of the total myopia reduction program. Therapy which teaches the patient voluntary control of their accommodative and vergence systems should be emphasized. Visualization and imagery techniques combined with accommodative-vergence training may be beneficial as well. An example uses a base-in demand vectogram and has the patient fuse the target then close his eyes and try to maintain the relaxed visual posture as long as possible. Techniques such as these allow the patient to internalize the feeling of relaxed vision and enable them to use these methods during times of visual stress. Tachistoscopic training may be beneficial as well. Studies have shown an improvement of visual acuity through the use of "tach" training. The goal of this type of training is image processing and internalization, so that the patient develops the skill of creating clear images in his own mind. Tachistoscopic training can be successfully combined with plus lens and base-in prism demands to enhance the overall training effect. For a complete listing of various myopia reduction vision therapy techniques see the table of appendices.

Holistic aspects which should be emphasized include general stress reduction techniques such as progressive relaxation, meditation, and a daily exercise program. Bates techniques for vision improvement may be helpful to relieve eye muscle tension. Bates techniques include palming, swinging, sunning, and blinking/breathing. Kaplan[71] uses "self-hypnosis" to enhance the patient's ability to interact with their world. Positive suggestions are provided for the patient to encourage self confidence and should be provided on tape for the patient to use at home. Regular use of this positive feedback approach may draw on the self-healing potential which resides in all of us. If an individual is able to change his myopic behavior patterns he will have an increased chance of improving his vision. A fairly strict diet should be followed in order to maximize the effects of the reduction therapy. Natural foods are recommended. Red meat, excessive sugar, caffeine, alcohol, and preserved foods should be avoided.

Visual acuity training and accommodative biofeedback training may be helpful as an adjunct to a myopia reduction program. Both methods are non-invasive and have been shown in the literature to produce improved levels of visual acuity.

Orthokeratology may be a beneficial aspect of a reduction program, especially for those patients with low amounts of myopia who need to pass a vocational entrance visual acuity test. Patients should be informed that a retainer lens may need to be worn in order to maintain the improved level of unaided acuity. The effects on corneal physiology also need to be carefully discussed with the patient before deciding upon this treatment strategy.

Patients will likely inquire about the effectiveness of refractive surgery. Radial keratotomy, according to the literature, is most successful in treating low to moderate myopia. If a person is interested in this mode of therapy, we are obligated to inform him in a non-biased manner of the potential risks and benefits of the procedure. Alternative therapy options should be discussed as well. By doing this the patient is able to make a decision based on reasonable expectations and an appreciation for the possible short term and long term complications. The ultimate decision as to which course of therapy to follow ultimately depends on the patient's own personal goals. Our job as vision care professionals is to educate and inform the patient about all available modes of therapy.

The following are some guidelines for a myopia reduction treatment program;

MYOPIA REDUCTION:

1. Goal is to reduce or eliminate the amount of measureable myopia and to improve unaided distance visual acuity.
2. Recommend distance lens power to be "peeled off" to 20/40. A 20/20 or 20/25 prescription is to be used for driving only.
3. A nearpoint lens prescription, if indicated by nearpoint analysis or other testing, may be beneficial in negating the reduced distance acuity associated with nearpoint visual stress. Single vision spectacles are recommended for nearpoint work and should be worn as often as possible to elicit a more relaxed, passive viewing style.
4. A vision therapy program with emphasis on voluntary control of the accommodative and vergence system is recommended. Visualization and imagery techniques as well as tachistoscopic training may prove beneficial for a myopia reduction program.

5. Visual acuity training and accommodative biofeedback training to improve unaided distance acuity and possibly reduce the amount of measureable myopia.
6. Orthokeratology
7. Proper visual hygiene may be helpful in negating some of the effects of nearpoint visual stress.
8. General stress reduction techniques such as progressive relaxation, meditation, and a daily exercise program.
9. Bates vision improvement techniques such as palming, swinging, sunning, and blinking/breathing.
10. A strict diet which includes mainly natural foods.
11. Self hypnosis or positive feedback to enhance self confidence and draw on the individual's self-healing potential.
12. Refractive surgery

Chapter 21.
CONCLUSION

Myopia has been "treated" through the use of concave compensatory lenses for so many years that it is now considered normal to receive a lens prescription to clear distance visual acuity as soon as blur is noticed. The health care profession has made great strides over the past two decades by promoting preventative care. Vision care practitioners, for the most part, discourage preventative and remedial treatment options for refractive conditions. It may be time for our profession to look beyond the one dimensional approach of treating myopia with compensatory concave lenses. A multi-dimensional approach which emphasizes prevention, control, and reduction and addresses multiple proposed etiological factors may be an answer. After over a hundred years of treating this visual condition, it is unfortunate that the optometric profession is without a universally accepted approach for controlling myopia.

Furthur investigation of how mental states influence the perception, personality, and performance of myopic individual's is needed. A holistic model which considers the whole individual instead of only his visual system may be part of the answer to solving this piece of the myopic puzzle. A treatment plan which encourages the patient to take the responsibility of becoming an active participant in his own vision care through practicing proper visual hygiene habits and making positive lifestyle changes may elevate the individuals sense of well being.

In the future, our profession may want to rethink some of its conventional ideas which have been passed down through the generations concerning the cause and treatment of myopia. It is not the purpose of this paper to criticize the current optometric approaches to myopia control, but rather to propose a holistic integrative model for treatment which can, in the future, be investigated in a controlled clinical setting. A number of treatment options have been discussed throughout this paper. It is the optometrist who is in the unique position of having the knowledge and qualifications needed to coordinate these various treatment options into a successful treatment plan.

PART FIVE

TABLE OF APPENDICES

APPENDIX A
VISION THERAPY METHODS

The use of a nearpoint lens prescription to decrease accommodative demand and place the accommodative-vergence system in better balance is often the cornerstone of a successful myopia control program. Vision therapy may be a useful tool for the optometric clinician to increase the overall efficiency of the visual system and to better withstand the effects of nearpoint visual stress. Vision therapy can be useful for prevention, control, and reduction therapy programs.

Appendix A includes a brief description of a number of vision therapy techniques which may be useful in a clinical setting. The various techniques are catagorized according to the visual skill which is being trained. The five visual skills to be emphasized are:

1. Accommodation
2. Vergence
3. Ocular Motility
4. Peripheral Awareness
5. Visual Acuity Training

ACCOMMODATION

When working with a patient, initial emphasis should be on equalizing the accommodative facility of both eyes. When the patient has reached the level of having adequate accommodative facility, emphasis should then be placed on teaching the patient to effectively stimulate and inhibit accommodation at will. A successful patient will be able to inhibit accommodation in order to attain clearer vision while involved in everyday activities. Accommodative therapy should follow the order of monocular - bi-ocular - binocular.

1. Monocular Accommodative Rock

A number of methods can be used to produce increased levels of accommodative facility. The goal of monocular therapy is -6.00 and +2.50 accommodative ranges. The following are just a few of the methods which may be used:

a. Near - Far Rock
b. Loose lens Rock
c. Near - Far Rock with Lenses

<u>2. Voluntary Control of Accommodation</u>

The following methods may be helpful in teaching the patient to voluntarily stimulate and relax their accommodative system:

a. Cross cylinder accommodative feedback.

Patient wears a trial frame with +1.50 -3.00 x 90 in front of one eye while the other eye is occluded. The patient is asked to view a cross cylinder nearpoint card, and report which lines are darker and clearer. If the patient reports the vertical lines as being clearer, he is actively accommodating. If he reports the horizontal lines as being darker he is inhibiting accommodation. The patient is now asked to reverse the clarity of the lines as quickly and effortlessly as possible. As the patient becomes more successful, cylinder power can be reduced, which results in a higher level of difficulty.

b. Transparent card with accommodative demand.

Patient is to monocularly clear and blur the letters on a transparent target. The patient is continually asked how it feels when the letters are clear? When blurry? The transparent card can be placed on a window to help the patient internalize the feeling of relaxed accommodation.

c. Minus lens - clear/clear.[147]

Patient is to view a letter chart monocularly at 8 ft. through their present lens prescription. Patient must work to keep chart clear upon the addition of minus lenses ranging from -2.00 to -12.00 D, in .50 D steps. Patient is to work towards being able to maintain clarity for 10 seconds both with the lens and without the lens. The successful patient will be able to "focus" and "unfocus" slowly showing greater control of the accommodative system.

d. Minus lens - clear/blur.[147]

Patient is now asked to alternately focus and maintain clarity for 10 seconds and then unfocus and maintain the blur for ten seconds through minus lenses. This procedure should begin with high minus lenses through which it is relatively easy to maintain blur through (inhibition of accommodation). The successful patient will be able to alternately clear and blur -1.00 to -2.00 D lenses. The therapist can moniter the patient by observing the occluding eye for pupillary dilation or reduced convergence during the inhibition phase of the accommodative training.

e. Maximum blur with overminus.[147]

Patient is to view a letter chart monocularly at eight feet through a range of minus lenses over an uncorrected myopic eye. The patient first clears the chart through the minus lens and holds it. The lens is now removed, resulting in a very blurred image. This is used to demonstrate the effects of accommodation on distant visual acuity. Next, using the same lens the patient is asked to attain a maximum blur through the lens by inhibiting accommodation. The lens is removed and the patient notices a brief improvement of unaided acuity. This is used to demonstrate the acuity potential of an unaccommodated eye.

f. Eye closure accommodative inhibition.

The patient is now taught to substitute eye closure for the maximum blur through the minus lens phase. If the patient has internalized the feeling of inhibited accommodation, he can now simply close his eyes and visualize a distant scene. After approximately ten seconds the successful patient will be able to open his eyes and achieve a flash of clarity obtained via maximum accommodative inhibition. With practice the patient will be able to prolong this flash of clarity.

g. Selective clarity with minus overcorrection.[147]

Patient views monocularly through their present lens prescription and an additional minus lens (-6.00, -4.00, -2.00). The patient is asked to move around the room and maintain relaxed accommodation (blur) through the minus overcorrection. The therapist randomly chooses objects throughout the room for the patient to selectively clear. After attaining the clear vision, the patient then relaxes accommodation and resumes generalized viewing around the room. The successful patient will be able to selectively stimulate and inhibit accommodation through decreasing amounts of minus lens power.

VERGENCE

When working with a patient, early emphasis should be on anti-suppression work. The patient should be taught that active suppression represents binocular inefficiency. The goal of this first phase of vergence training is to attain maximum binocular blending or luster under various viewing conditions. Following anti-suppression training, the goal of vergence therapy is to expand vergence ranges, with emphasis on base-in training, and then teach the patient to voluntarily control his vergence system. The following are only a few of the techniques which may be used to achieve these therapy goals.

1. Anti-suppression training

Phase 1: Stimulation of poorer eye

a. Single vectogram (i.e. spirangle, topper) for eye that is suppressing and filter over eye which is not suppressing.

b. Single piece of red filter on a target with glasses having no filter on poorer eye and a green filter on the better eye.

Phase 2: Alternate stimulation to both eyes

a. T.B.I.

b. Frequent blinking

c. Alternate Pola-mirror

Phase 3: Simultaneous Perception

a. Troposcope

b. TV trainer

c. Bi-ocular motility and bi-ocular accommodation training

d. Split vectograms

Phase 4: Peripheral fusion

a. Vectograms

b. Binoco cards

c. BU cards

d. Brock posture board

Phase 5: Central fusion

a. Cheiroscopic tracings

b. AN cards

c. Flat fusion cards with suppression controls

2. Vergence range extension

Range extension therapy should emphasize base-in training. Training should be done in the distance as well as at near. Methods which may be used to train distance base-in vergence include projected vectograms and base-in training through plus lenses. The following are other vergence techniques which may be useful. If a point is reached during the training sequence where little improvement in base-in ranges is seen, introduce visualization, imagery, and relaxation techniques to compliment vergence training.

a. Vectograms
b. Tranaglyphs
c. EC, AN & BU cards
e. Brock string
f. Aperture rule

3. Voluntary control of the vergence system

The goal of vergence training is to teach the patient to project his vergence system out into space in order to voluntarily call on negative vergence and related negative accommodation. The ultimate goal of myopia vision therapy, according to Birnbaum, "is to place the systems of accommodation and convergence in better balance, by increasing the freedom of action between the two systems so that stress on one has less effect upon the other." The following are some methods which may be used to train voluntary control and awareness of the vergence system.

a. Base-in awareness

Patient is to view base-in targets such as EC 110-112, BC 51-54, and BI aperture rule. Targets may be viewed with plus lenses to enhance the base-in effect as well as accommodative relaxation. The successful patient will be able to eventually internalize the feeling of projecting the vergence system out into space.

b. Voluntary vergence

While viewing various vergence targets the patient is asked to blur and clear the targets voluntarily. The patient is also asked to induce divergent diplopia and then make the target single voluntarily. The successful patient will have sufficient control of their vergence system so that they can make an object become clear or blurry, and single or double through the use of base-in or base-out vergence.

c. Brock string

Patient is asked to make small jump vergence movements from bead to bead. A higher order skill is then to be able to make smooth controlled vergence movements from one bead to another. A metronome is helpful during this technique in order to enhance the fine control of the vergence movements.

d. Eccentric circles & Lifesaver cards

Patient is to fuse the circles in free space. When patient is able to fuse all circles, base-in and base-out, movement of the card in space and tromboning techniques may be added.

e. Double vectogram jumps with +/- lenses.

Two vectograms are presented to the patient, one with a base-in demand and the other with a base-out demand. The patient views the base-in vectogram through minus lenses and the base-out vectogram through plus lenses. The successful patient will eventually be able to alternately fuse as well as make spatial and size judgements quickly and accurately.

f. Loose prism voluntary vergence control

The patient views a target through a 15 diopter prism BO. The patient is taught to resist the fusion response and maintain diplopia. When this is accomplished, the patient is taught to fuse and hold for ten seconds and then unfuse and hold diplopia for ten seconds while the prism remains in place. While experiencing diplopia, the images seen by the patient should be equally blurred and separated from the center.

g. Closed eye vergence posture

Patient views a base-in demand vergence target then closes his eyes and attempts to maintain the base-in visual posture. Upon opening his eyes, the patient should be able to immediately fuse the vergence target. The successful patient will eventually be able to use eye closure alone to achieve the desired visual posture, and be able to use this ability in everyday viewing tasks.

OCULAR MOTILITY

Because it has been reported that myopes tend to lock themselves into a central "stare" and constrict the periphery, ocular motility training may be a beneficial adjunct to a myopia vision therapy program. The goal of ocular motility training is to allow the patient free, easy, and accurate eye movement abilities.

a. Yoga eye movements and rotations

The patient should sit or stand in an upright position, maintaining good posture and proper breathing patterns at all times. The patient is asked to turn his eyes as far as possible to the right producing a feeling of strain and tension. The patient now exhales deeply and moves his eyes all the way to the left position of gaze. This cycle is repeated for ten breaths. Similar cycles in all cardinal positions of gaze should be completed. Finally a series of rotational eye movements should be executed to complete the exercise.

b. Fixations

The patient stands in front of a wall and chooses two fixation targets across the room to alternately fixate. When the patient is able to successfully complete this task, a metronome is added so that the patient is required to adjust his fixation rate to the beat of the metronome. When this portion of the exercise is done with ease, have the patient become aware of his breathing and blinking patterns while continuing with the fixation task. The successful patient will be able to incorporate accurate fixational ability with time planning (metronome) as well as proper breathing and blinking patterns.

c. Figure 8's

The patient is asked to stand comfortably being aware of his posture and breathing patterns. With eyes closed the patient is to visualize a large figure eight in the distance. Now, with eyes closed the patient is to trace a vertical figure eight for five to ten breaths then a horizontal figure eight for five to ten breaths, and finally a "racetrack" figure eight which comes very close and extends out into the distance. The procedure is then repeated with eyes open. The patient should be asked which type of figure eight pattern is more difficult to trace?, Which is easier, eyes open or closed? Is there any tension noted in the body, specifically the back, shoulder, or neck? The succesful patient will be able to trace the figure eight patterns effortlessly and accurately with eyes open and closed.

PERIPHERAL AWARENESS

Wallman[82] has theorized that the develpment of myopia may be associated, at least in part, to a deprivation of the peripheral retina. Forrest[53] has noted that functional myopes tend to be central or eso processors who tend to emphasize figure over ground. Because of this body of literature, peripheral awareness training has been included as a component to the integrative myopia control program. The following methods may be helpful to enhance peripheral awareness.

a. Form recognition fields

Patient is to occlude one eye and hold a form recognition card, such as the MacDonald card, at a distance of 13" in front of the open eye. The patient is asked to fixate the central letter and simultaneously recognize as many of the peripheral letters as possible. The successful patient will expand the amount of visual information that may be comprehended per given unit of time.

b. Concious peripheral awareness

Patient is instructed to include an awareness of his surrounds into his daily routine. An example would be to conciously be aware of as many details as possible of people beside him while walking along the sidewalk. Is it a man or woman?, What color is his tie?, Is he carrying a briefcase?, etc. The successful patient will notice an increased ability to notice peripheral detail.

c. Awareness of surround while reading

The patient is instructed to shift his awareness to the white background instead of the black print while reading. The print should seem to float off of the page, and an increased awareness of the periphery should become evident. The successful patient will be able to read with a more relaxed and easy visual style, as well as be able to transfer the concept of awareness of the background to everyday viewing tasks.

d. Thumb awareness

A simple technique in which the patient simply holds both arms outstretched to the sides of the body with the thumbs pointed upwards. The patient is to separate the thumbs as far apart as possible while still being aware of them. This technique can be added to other distance viewing vision therapy techniques to emphasize a more peripheral visual style.

VISUAL ACUITY TRAINING

Much attention has been given to visual acuity training in the psychological literature. Up to four Snellen lines of acuity improvement have been reported. The basic procedure involves the patient learning to identify letters on a distant chart while progressively increasing the distance between himself and the chart. Another factor which is included in many of the training sessions is positive verbal reinforcement for correct answers given by the patient during the procedure. The following are two methods which may be used by the optometrist to train visual acuity.

a. Letter chart walk-aways

The patient stands at a distance from the letter chart where he can see all the letters clearly without his lens correction. The patient now walks away from the letter chart, reading the letters aloud, until the chart becomes blurred. At this point the patient slowly moves toward the chart until the letters can first be identified. This sequence is repeated with the patient trying to increase the distance between himself and the chart while still being able to correctly identify the letters. The successful patient will be able to improve his ability to interpret distance blur.

b. Explosions

The patient stands at a distance from the letter chart where he can just barely identify some of the letters without his lens correction. The patient is instructed to produce tension throughout his eyes, face, and whole body. The patient is asked to hold this tension for a period of ten to twenty seconds while viewing the letter chart. He is then told to release with a sudden "explosion" of tension relief. As the tension throughout the body is released the patient is instructed to call out as many of the letters on the chart as possible. The successful patient will develop an increased awareness of bodily tension and become more aware of the effects of tension on distance visual acuity.

c. Telebinocular acuity training

The patient is seated in front of a telebinocular which is set for infinity. Without a lens correction in place, the patient is instructed to use such techniques as accommodative relaxation, projection of the vergence system out into space, "easy looking", visualization, imagery, etc. in order to clear the acuity demands on the Keystone stereo card. The successful patient will be able to progressively clear more of the stereo card throughout the course of his myopia therapy program.

Appendix B
VISUAL HYGIENE

Instruction on proper vision hygiene should be an important aspect of any overall myopia control program. A hygiene sheet or booklet can be given to myopic patients as reminders for proper vision habits. A visual hygiene videotape shown to patients, while still in your office, can make a lasting impression. These vision hygiene suggestions may help to reduce or prevent the development of a visual problem which may manifest as functional myopia. Possibly the most beneficial aspect of the visual hygiene program is the inclusion of the patient in his or her eyecare program. By instructing your patients on proper visual habits you are making them an active participant in their vision care.

The following is an example of some common visual hygiene guidelines which may be incorporated into a myopia control program:

1. READING DISTANCE

Maintaining a proper working distance while involved in near tasks is essential. It is recommended to read no closer than the distance from the middle knuckle to the elbow (Harmon's distance). The reading material should be placed in such a manner that the right and left sides are equally distant from the eyes. As the reading distance becomes shorter, the accommodative demand on the visual system becomes greater. Stress on the visual system is reduced when reading is done at a proper distance.

2. POSTURE

20% of the retinal fibers lead to the posturing mechanisms of the body, therefore the importance of good posture as it relates to vision should not be overlooked. Proper reading posture involves sitting upright with both feet resting flat on the floor, the lower back should be properly supported, and reading material should be held in one's lap or on a slant board tilted at about 20 degrees from the horizontal. Other reading postures such as lying on the floor or reading in bed should be avoided. Proper posture will allow fuller easier breathing and greater nearpoint sustaining ability.

3. ILLUMINATION

Proper lighting may result in less energy being spent while reading and a decrease in the need to bring reading material closer. A reading lamp combined with adequate general room illumination is advised for all reading tasks. Full spectrum lighting may reduce visual fatigue and enhance efficiency.

4. REST BREAKS

Taking regular rest breaks while reading may be helpful in reducing levels of nearpoint visual stress as well as in preventing accommodative spasm. Looking up at the end of every paragraph or page and clearing an object located at least 15 to 20 feet away may allow an individual to increase the length of time he or she can function efficiently at near. A 1-2 minute break every 20 minutes in which the individual can get up and walk around or stretch, will further enhance the ability to sustain for longer periods at near as well as possibly preventing the development of functional myopia due to accommodative stress.

5. BLINK & BREATHE

Breathing often becomes shallow under conditions of increased visual attention such as reading, writing, or computer use. Shallow breathing may result in added tension in the body, especially the shoulders and neck, and may reduce the ability to sustain attention and concentration for extended periods of time. Rhythmic deep diaphragmatic breathing may aid in increased sustaining ability at near as well as a decrease in overall stress levels throughout the body.

In addition to shallower breathing, many individuals tend to show a decrease in their blink rate when involved in a nearpoint task which requires large amounts of visual attention. This decreased blink rate can result in tired, burning, itchy red eyes. Reminders posted to the computer terminal or on a bookmark may serve to help an individual maintain a healthy blink rate while involved in nearpoint tasks.

6. EYE & NECK ROTATIONS

Eye and neck musculature often becomes fatigued while an individual is exposed to prolonged nearpoint work. To help alleviate and prevent this strain, simple stretches designed to relax the musculature of the eyes and neck can be implemented during reading breaks. While the eyes are closed, move them in a figure eight pattern, first vertically and then horizontally. Rotate the eyes 5 to 10 times in each direction, remembering to breathe throughout the exercise. Next rotate the head in a figure eight pattern, first side to side and then in a forward direction. Rotate the head and neck 5 to 10 times in each direction. This simple stretching exercise will help to realign the muscles and bones of the neck, as well as reduce overall stress and tension.

7. MASSAGE

A gentle massage of the forehead, cheeks, eyelids, and bridge of the nose may help reduce levels of visual fatigue. While breathing deeply, close the eyes and use the fingertips of both hands to gently relax tense facial muscles. A two minute massage incorporated into regular nearpoint breaks may serve to relax the facial musculature as well as reduce the nearpoint stress response.

8. PALMING

A technique introduced by William Bates to enhance overall eye / mind relaxation. Begin by gently rubbing your palms together to generate warmth. Place the warm palms over your closed eyelids, without pressing against the eyes but rather gently resting on the bony ridge surrounding the eyes. Relax, breathe deeply, and feel the eyes give up the tension of trying to see. Memorize the feeling associated with palming and try to call on this relaxed feeling when involved in sustained nearpoint work. Palming may be incorporated into normal nearpoint breaks.

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