CLINICAL MANAGEMENT OF THE MYOPIC PATIENT

Myopia has long been a source of considerable concern to both patients and practitioners. As myopia progresses, unaided visual acuity diminishes, dependence on corrective lenses increases, corrective lenses become increasingly thick, and the axial length of the globe increases, with increased risk of ocular disease. Consequently, researchers, clinicians, and patients have each been concerned with myopia prevention and control. In this issue Dr. Arnold Sherman of the State University of New York College of Optometry takes an aggressive position with regard to myopia control (beginning on this page); Dr. Theodore Grosvenor of the Indiana University School of Optometry stakes out a more conservative position (beginning on page 19). Together, the two papers serve to illuminate the current status of the controversy.

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MYOPIA
CAN OFTEN BE
PREVENTED, CONTROLLED OR ELIMINATED

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ABSTRACT
Myopia is increasing in prevalence in both children and adults. Myopia is commonly associated with sustained concentration at nearpoint, and progression may be aggravated by use of minus lenses. The literature on use of bifocals and vision therapy to control myopia progression is reviewed. A clinical approach is described for myopes up to 1.5 D who have not used minus lenses. The regimen includes: (1) no distance lens correction, (2) single vision lens prescription for sustained near work, (3) visual hygiene procedures, (4) vision therapy, and (5) proper nutrition and aerobic exercise.

KEY WORDS
myopia, myopia control, vision therapy, nutrition, visual hygiene

Myopia exists in approximately 25% of the population and is increasing in incidence in both children and adults.[1] At least 20% of previously non-myopic individuals become myopic during college or in the military academies.[2-4] Adult-onset myopia is frequently a problem for military academy students seeking to become pilots.[3,4] A prevalence of myopia as high as 80% has been reported in professional students.[5,6]

Myopic individuals are dependent upon "corrective lenses." Myopic children may experience social and psychological problems due to negative peer influence as well as limitations in participating in contact sports such as baseball, basketball, football and lacrosse. Due to exclusion from these sports, myopes may become loners.

Myopia is also a concern due to the high incidence of ocular pathology, including glaucoma, vitreous degeneration and retinal detachment. It has been estimated that myopia is the sixth leading cause of blindness.[7]

BEHAVIORAL PHILOSOPHY

Over 50 years ago, Skeffington[8] stated that sustained concentration at nearpoint tasks is socially compelled but is biologically unacceptable, resulting in stress to the organism and causing symptoms and vision problems. Some individuals develop pseudomyopia as an adaptation to this stress in order to achieve at nearpoint tasks. This adaptation may persist even after the task demands cease, causing true myopia. Harmon[9] indicated that stress may alter function, and that altered function may ultimately alter structure.

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THE RESULTS OF MYOPIA CONTROL STUDIES HAVE NOT BEEN ENCOURAGING

Theodore Grosvenor, O.D., Ph.D.

ABSTRACT

The literature on myopia control includes many reports concerning individual patients or small numbers of patients, but not many reports of well-designed large-scale prospective clinical trials. Studies evaluating methods of controlling the progression of childhood myopia have shown that the wearing of bifocal lenses is effective in controlling progression for myopic children who are esophoric at nearpoint, and that rigid contact lenses are moderately effective in controlling or delaying progression. Studies evaluating methods of reducing the amount of existing myopia have shown that the wearing of rigid contact lenses fitted flatter than the cornea may be effective in reducing myopia if retainer lenses are worn on a regular basis. However, to date there has been no convincing evidence of the effectiveness of conventional vision therapy, biofeedback training, or the daily use of pharmaceutical agents in reducing the amount of myopia or its rate of progression.

KEY WORDS

myopia, myopia progression, myopia control, bifocals, orthokeratology, biofeedback training

As vision care practitioners we would like nothing better than to be able to control myopia. Unfortunately, the literature contains relatively little firm evidence that the methods advocated for this purpose are effective. When considering this literature, it is important to differentiate between those methods designed to *control the progression* of myopia from those methods designed to *reduce the existing amount* of myopia. Methods designed to control progression--the wearing of bifocals, the instillation of atropine and other pharmaceutical agents, and the wearing of conventionally-fitted contact lenses--have been applied mainly to young myopes, whereas methods designed to reduce the existing amount of myopia--conventional vision therapy, biofeedback training, and orthokeratology--have been applied to myopes of all ages.

METHODS DESIGNED TO CONTROL THE PROGRESSION OF MYOPIA

The belief that myopia is brought about by *excessive accommodation* forms the rationale for the use of bifocal lenses, as well as the use of atropine and atropine-like agents for the control of myopia progression. The rationale for the use of conventionally-fitted contact lenses is based on the fact that these lenses tend to cause *corneal flattening*, thereby reducing (or delaying) progression.

Bifocal Lenses

Conflicting results have been reported in studies of bifocal lenses for the control of myopia progression. In a retrospective study, Oakley and Young[1] reported progression rates for Native American and Caucasian children, respectively, of 0.37 D and 0.50 D per year for single vision lenses, as compared to 0.11 and 0.02 D per year for bifocal lenses. However, prospective clinical trials of the use of bifocals have shown far less encouraging results. In a randomized prospective clinical trial, Grosvenor et al.[2] found no significant differences in annual progression rates for three groups of myopes from 6 to 15 years of age: progression rates were 0.34 D per year for single vision lens wearers, 0.36 D per year for +1.00 D add bifocal wearers, and 0.34 D per year for +2.00 D add bifocal wearers. In another randomized trial involving 9-11 year-old myopes who had not previously worn a correction, Hemminki and Parssinen[3] found a higher mean progression rate for subjects wearing single vision lenses for distance use only (0.78 D per year) than for those wearing single vision lenses for constant use (0.59 D per year) or those wearing bifocals (0.58 D per year).

The results of three myopia control studies were analyzed by Goss and Grosvenor,[4] on the basis of near phoria findings. Data for the three studies showed that for children with nearpoint esophoria through the distance correction, the mean rate of progression was about 0.20 D per year less for bifocal wearers than for single vision lens wearers; whereas for children with nearpoint orthophoria or exophoria, there was no significant difference between progression rates for single vision and bifocal wearers.

Pharmaceutical Agents

The daily instillation of atropine and other pharmaceutical agents has been advocated for controlling the progression of childhood myopia. The theoretical basis of the use of atropine and atropine-like agents is similar to that for the use of bifocals: if myopia is brought about by over-accommodation, the relaxation of accommodation by such an agent should

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reduce the rate of progression. However, the use of these agents presents many practical problems, including the need for bifocals or reading glasses for near work, sensitivity to light as a result of the constant mydriasis, and the possibility of allergic dermatitis and other side effects.[5] At least two studies making use of atropine have shown a low rate of progression while the drug was being used, followed by an increased progression rate after its discontinuation. A study reported by Brodstein et al.[6] involved an experimental group of 435 myopic children who were fitted with +2.25 D add bifocals and were given one drop of 1% atropine in each eye every morning, and a control group of 146 myopic children wearing single-vision glasses and not given atropine. It was found that for the experimental group myopia progressed at the rate of 0.16 D per year during treatment but at the rate of 0.30 D per year after treatment, as compared to 0.25 D per year for the control group. In another study, Gruber[7] reported data on 100 myopic children who used 1% atropine daily as compared to an equal number of control children. The children in the experimental group progressed at a mean rate of 0.11 D per year during treatment but at the rate of 0.46 D per year after treatment, while those in the control group progressed at a mean rate of 0.28 D per year. Gruber et al. concluded that if atropine is to delay the progression of myopia, it must be started early and continued for a period of five to 10 years.

Because accommodation has been shown to bring about an increase in vitreous chamber pressure, causing axial elongation,[8] the daily instillation of timolol maleate has been suggested as a method of controlling myopia progression. In a pilot study involving 10 myopic children who were treated with one drop of 0.25% timolol maleate twice each day, Jensen and Goldschmidt[9] found that the treatment had very little effect on intraocular pressure, and that while a few of the children seemed to progress at a lower rate while on the timolol treatment, it was difficult to judge whether or not the treatment had been successful.

Conventionally-fitted Contact Lenses

Although polymethyl methacrylate (PMMA) contact lenses have been recommended for myopia control since Morrison's 1956 report,[10] the first comprehensive clinical trial making use of these lenses was Stone's five-year study,[11] reported in 1976. Stone fitted 84 myopic children with PMMA contact lenses and compared rates of progression for these subjects to those of 40 myopic children who wore glasses. For those remaining in the study for the five-year period, mean rates of progression were approximately 0.10 D per year for contact lens wearers and 0.37 D per year for spectacle wearers.

In the only reported study of the use of conventionally fitted rigid gas-permeable contact lenses for myopia control, Perrigin et al.[12] fitted 100 myopic children between the ages of 8 and 13 years with Paraperm O_2 plus lenses. For 56 subjects remaining in the study for three years, mean annual progression was 0.16 D per year as compared to a mean annual rate of 0.51 for a group of 20 spectacle wearers matched for age and amount of myopia. The authors[13] reported that for 23 subjects who discontinued lens wear for an average period of 10 weeks (wearing spectacles during this period), then resuming lens wear with Fluoroperm lenses for a period of eight months, mean progression was 0.27 D during the period of non-wear but only 0.02 D during the subsequent period of Fluoroperm lens wear. The authors concluded that rigid gas-permeable contact lenses can have a statistically significant effect on myopia progression, even if lens wear is discontinued for a short period of time.

METHODS DESIGNED TO REDUCE THE EXISTING AMOUNT OF MYOPIA

As with bifocals and atropine, the rationale for both conventional vision therapy and biofeedback training is that myopia is brought about by excessive accommodation. The rationale for orthokeratology is that of designing lenses that will cause corneal flattening, and possibly also a reduction in the axial length of the eye.

Conventional Vision Therapy

Vision therapy for the reduction of myopia was popular during World War II, when many myopic young men wanted to be accepted by one of the armed forces. The only large-scale study of conventional vision therapy for myopia reduction was The Baltimore Myopia Project, conducted in 1944. One hundred and eleven unselected subjects were recruited, ranging in age from 9 to 32 years and having from 0.50 D to 9.00 D of myopia. The training procedures were administered by optometrists and technicians under the sponsorship of the American Optometric Association, and cycloplegic refractions were done prior to and after completion of the training by ophthalmologists at the Wilmer Eye Institute. In the official optometric report of the study, Ewalt[14] published a series of graphs showing an average improvement in visual acuity of two or three lines of letters. In the official ophthalmological report, Woods[15] reported pre- and post-training retinoscopy findings on 67 subjects. If we assume that retinoscopy findings are repeatable to within 0.25 D, inspection of Woods' table shows that 15 of the 67 subjects increased in myopia between the "before" and "after" refractions, while five decreased in myopia and 47 remained the same.

Biofeedback Training

In biofeedback training, the patient is presented with a visual stimulus in an "open-loop" situation, usually by means of an infrared optometer, and an auditory stimulus is used to indicate to the patient whether his or her accommodation is increasing or decreasing. To date, the results of two comprehensive studies, using this approach, have been published.

Galloway et al.[16] reported on a study making use of the Accommotrac Vision Trainer, involving 11 myopic subjects. Improvements in uncorrected acuity were found for most of the nine subjects who completed the study; however, there were no changes in refractive error. Galloway et al. suggested that the improvement in visual acuity may have represented learning effects in measuring visual acuity. Before beginning the training, the acuity of each subject was measured several times to establish a base line, and it was found that visual acuity for several subjects improved with repeated testing in these pre-training sessions.

Koslowe at al.[17] reported on a double-masked study making use of the Accommotrac instrument, involving experimental and control groups of 15 myopic subjects each. The treatment was similar for the two groups, with the exception that members of the control group were not provided with feedback that could be linked to their accommodation. No significant differences were found between the two groups in changes in unaided visual acuity, retinoscopy, or subjective refraction. Koslowe et al. made the point that previous reports--other than the Galloway et al. study--were "a mixed group of case reports, studies not involving myopia, reviews, unpublished material, and record review from a private practice."

Orthokeratology

The vision care literature contains two prospective clinical trials of orthokeratology. Kerns[18] reported on a study in which one group of subjects (36 eyes) made up the experimental group, and another group (26 eyes) made up the control group. To initiate orthokeratology changes, the experimental subjects were fitted with larger, thicker, and flatter lenses than the control subjects. After somewhat more than one year, mean changes for the experimental group were (a) a decrease in myopia (spherical equivalent refraction) of 0.87 D and (b) an increase in with-the- rule refractive astigmatism of 0.42 D. Kerns noted that the standard deviations were so high that it would not be possible to predict changes comparable to the mean changes for any given patient.

Forty experimental (orthokeratology) subjects and 40 control subjects were fitted with contact lenses by Polse et al.[19] Subjects in both groups were followed for 18 months. Experimental subjects were fitted with larger and thicker lenses, and were fitted flatter than the control subjects. The subjects were not told whether they were in the experimental or control group: "mock" lens changes were made for members of the control group (whereas real lens changes were made for members of the experimental group). For the experimental subjects, myopia was found to reduce by an average of 1.00 D as compared to 0.50 D for the control subjects. Polse et al. found that the reduction in myopia was not permanent, requiring the use of retainer lenses (worn a part of each day) to perpetuate the effect.

RECOMMENDATIONS

For the majority of our myopic patients, the appropriate form of management is to prescribe lenses that will provide adequate distance acuity. However, in the light of the results reported in the literature, the following recommendations may be helpful.

Bifocals

For young people who are esophoric at nearpoint the use of a bifocal add, in addition to providing more comfortable near vision, may result in a somewhat lower rate of progression than if single vision lenses were worn.

Atropine and Other Pharmaceutical Agents

Because it is difficult, if not impossible, to continue the daily use of atropine or other pharmaceutical agents for the five to 10 years during which myopia is expected to progress,[7] and because any reduction in the progression rate is likely to be reversed after discontinuation of the drops,[6,7] the use of these agents is not recommended.

Vision Therapy

Inasmuch as there have been no convincing studies showing that either conventional vision therapy or biofeedback training are effective in reducing the amount of objectively- or subjectively-measured myopia, these methods should be used only with the understanding that the only advantage may be improved visual acuity--and that the improved acuity may very well occur, as noted by Gallaway et al.,[16] as a result of the patient having memorized the letters on the chart.

Conventionally-fitted Rigid Contact Lenses

For the young myope who is motivated to wear contact lenses, there is a good chance that the use of rigid gas-permeable lenses will result in a slower rate of progression than would occur otherwise.[12,13]

Orthokeratology

For the older myope who would like to be less dependent upon glasses or contact lenses, and who understands that the effect is unpredictable and that retainer lenses will have to be worn in order to perpetuate the effect,[19] orthokeratology may hold some hope.

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Birnbaum[10] further defined the role of the autonomic nervous system and its reaction to stress and cognitive demands, which create an imbalance of the sympathetic and parasympathetic components. This leads to accommodative insufficiency and resultant overconvergence tendency. Myopia is a frequent end result of these mismatches.

I believe that an additional principle is required to explain the continued increase in myopia once the refractive condition is corrected. *When an adaptation is decompensated, a readaptation will occur in order to achieve steady state performance at near tasks, resulting in a further increase of myopia.* Therefore, the conventional wisdom concept, "Correct the refractive error," needs to be reassessed.

CURRENT RESEARCH

A good deal of recent research supports the Skeffington model. Leibowitz and Owens,[11] and Bullmore et al.[12] investigated changes in the level of tonic accommodation (dark focus), using the laser optometer. These studies indicate the existence of wide variations in dark focus among individuals, with an average of 1.5 D of myopia among emmetropic or corrected ametropic college students. Hyperopes have a nearer dark focus than emmetropes, who, in turn, have a nearer dark focus than myopes; however, after reading, myopes make a greater inward shift than emmetropes or hyperopes, with corresponding distance blur and measurement of increased myopia. This effect is similar to spasm or infacility of accommodation and has been termed "transient accommodative myopia" due to increased tonus. Ebenholtz[13] proposed that an inward shift of tonic accommodation, following near work, is a precursor of myopia. A similar effect occurs in the vergence system, with an inward shift in dark vergence following near work.[14] I believe that the synergistic relationship of these inward shifts produces the initial myopia and reduction in visual acuity.[15]

Young[15] proposed that myopia develops as a two-phased process: (1) a tonic change in the ciliary muscle, and (2) the increased tonus elevates pressure in the vitreous chamber, causing enlargement of the globe and increase in the axial length.

PREVIOUS STUDIES

A recent report reviews more than 500 articles on myopia and concludes that considerably more research is needed to answer specific questions, such as identifying variables that might predict refractive error changes in young adults.[1]

Numerous studies[16-23] regarding the prevention and control of myopia are confusing, at times misleading, and often diametrically opposed. Studies of the use of bifocals and pharmaceutical agents, for example, are based primarily on the premise of a single causative agent (excessive accommodation). The therapeutic approach is to reduce accommodation, with an arbitrary bifocal add, cycloplegic drug, or combination. However, it is likely that myopia has numerous causations,[24] including accommodation,[15,25] convergence,[26] extraocular muscle stress resulting in vitreous pressure increase,[27] mechanical weakness in posterior sclera,[28] diet,[29] accommodative-convergence and focal-ambient relationships.[30]

Another weakness in the literature on myopia control is that in many studies the lens addition is prescribed arbitrarily, without consideration of individual profiles of test data regarding lens acceptance and power. Among studies in which bifocal lens addition was determined arbitrarily, Oakley and Young[16] found a significant reduction in the rate of myopia progression, but Grosvenor et al.[17] and Hemminki and Parssinen[18] found no significant effect. Roberts and Banford[19] and Goss[20] performed studies in which the bifocal addition was determined on an individual basis and demonstrate lower rates of myopia progression with bifocals in myopic patients with nearpoint esophoria.

Significant individual variations occur in all studies and need to be thoroughly investigated. For example, inspection of the data for the +2.00 add group in the Houston Myopia Control Study[17] reveals that six of 22 patients showed no increase in myopia. It is quite possible that stabilization may have occurred without bifocals; yet one should question why a +2.00 arbitrary add stopped progression in these patients. A closer look at the analytical measures, including phorias and vergences, accommodative amplitude and facility, cross cylinder net, positive and negative relative accommodation, MEM, nearpoint acuity, and habitual reading distance is necessary to understand the significance of these findings in this successful group of patients. A prospective study is needed to evaluate these findings in relation to myopia progression for both experimental and control groups. Further, the examiner bias prevalent in many studies must be eliminated.[31]

The Baltimore Myopia Control Project[32,33] studied 111 patients, before and after a short-term vision therapy program, to determine whether myopia progression could be controlled and whether visual acuity could be improved. The average number of visits over a four-month period was 25. It is the only study that treated myopia by using a wide range of techniques designed to improve ocular motility, speed and span of perception, and central-peripheral awareness, as well as accommodative-convergence flexibility. The results of this study are subject to differing interpretations, depending upon the statistical methods used. The ophthalmological report authored by Woods,[32] indicated that 59% of the patients demonstrated improvements in visual acuity. The optometric report by Ewalt[33] reported gains in visual acuity in 90% of the subjects; these gains were maintained over a period of at least five months, at which time the study ended.

Upon reviewing the cycloplegic refractive findings in the Baltimore project, it is evident that 70% of the patients did not increase in myopia, 20% decreased and only 10% increased. The project clearly succeeded in the CONTROL of myopia in 90% of the patients, which corresponds to the acuity improvements reported by Ewalt.[33]

Avestisov,[34] at the Helmholtz Eye Disease Institute in Moscow, USSR, reported on the results of accommodative training on 1,956 school children, and found that training "helped to prevent or at least postpone the onset of myopia in an overwhelming majority of cases; after 25 years of observations, only 2.6% of high risk children who had taken accommodative training sessions presented with myopia, as against 31.1% among those who had not."

CLINICAL APPROACH

Operationally, one may classify myopia as follows:

1. Congenital
2. Adaptive
   a. Uncompensated (no minus prescription)
   b. Compensated

In my thinking, myopia that is not congenital may be viewed as adaptive and its increase iatrogenic due to the aggravating effect of minus lenses.

In order to prevent, control, or reduce myopia, clinicians must consider the use-abuse theory as well as the biological theory of myopia. More concern as to the etiology, prognosis, and therapy of myopia is required rather than simply asking, "How much minus needs to be prescribed for best acuity?" Until these changes in thinking are made, our patients will continue to increase at the rate of 0.33 to 0.50 diopter per year. The increase may be primarily iatrogenic, with the minus lens acting as a triggering mechanism for more myopia. This concept is supported by Angle and Wissmann[35] in their study of 2,177 children, age 6 to 11, controlled for age and educational level.

My approach for adaptive uncompensated myopes is as follows:

1. No distance lens "correction"
2. Nearpoint lens prescription for prolonged reading (more than 30 minutes) in single vision form
3. Visual hygiene procedures
4. Vision therapy
5. Proper nutrition and outdoor aerobic exercise

During the past decade, I have controlled myopia progression for approximately 50% of the myopes that present themselves with objective refractions up to -1.50 D, and not wearing minus lenses. I have also achieved success in reducing adaptive compensated myopes by as much as 1.00 D. Many of these patients become effectively emmetropic and discard their distance lens prescription.

These patients learn, via vision therapy, to self-regulate their visual system for specific task demands and readily accept uncorrected binocular visual acuity ranging from 20/30 at worst to 20/20 at best. They are comfortable, perform above average academically and in sports, and function at high levels of performance, satisfying their needs.

All of these patients are highly motivated. Younger children are actively encouraged by their parents, most of whom are myopic and remember their fear "of going blind" and "of worsening vision and stronger glasses."

Unfortunately, most patients do have crisis periods with poor distance acuity, asthenopia, and headaches due to increased stress and academic work, particularly in the middle of high school, first year of college, and in graduate or professional school. Short term "booster" training programs in the office are needed at such times, with increased compliance to hygiene, diet, and use of the nearpoint lens prescription. These periods subside as abruptly as they begin, without the need for a myopic correction.

Our success is in part attributed to the "look out the window" effect. My office has a large examination room, approximately 20 feet long and 15 feet wide, with a door that opens into a room with floor to ceiling windows, allowing distance viewing to one- half mile. Our routine is to initially record binocular visual acuity and then to open the door, asking the patient to be aware of peripheral vision and to look out the window as far as possible for 10 seconds. I then reassess binocular visual acuity. An improvement of one to two lines invariably occurs with a rapid decrement to the prior acuity. The technique is repeated once again and an explanation is immediately presented, discussing the beneficial effect on distance eyesight that will occur when vision is used appropriately. This demonstration sows the seeds for a vision therapy program with a highly motivated patient. Similar demonstrations are used when overconvergence occurs on Brock string, vectograms, and Van Orden Star testing.

Binocular acuity usually improves more than monocular acuity, suggesting changes in both the accommodative-convergence and central-peripheral mechanisms.

The size of an examination room creates both physiological and psychological changes. Rosenfield and Ciuffreda[36] demonstrated that knowledge of room size affects the dark focus, with smaller rooms inducing myopic shifts that disappear if subjects are blindfolded prior to entry into the examination room. Clinical experience in different sized examination rooms supports the concept that small, narrow rooms induce more myopic retinoscopic and subjective refractions.

VISUAL HYGIENE AND VISION THERAPY

It is beyond the scope of this paper to present the specific techniques used for visual hygiene and vision therapy. Generally, visual hygiene emphasizes proper reading posture and distance, rest periods after 20 minutes of reading, periodically shifting visual fixation to far objects for 20 seconds, proper lighting, and time limitations on television viewing and video games.

Home vision therapy techniques emphasize central-peripheral awareness. The patient is asked to "open up your visual world" in everyday activities such as walking and driving and to become aware of objects and distances between objects in the X, Y, and, most importantly, the Z, or near-far axes. Office procedures are programmed for self-generated movement and include accommodative- vergence flexibility out of instruments in free space. The use of windows and mirrors during accommodative and vergence procedures increases distance spatial awareness. Yoked prisms are routinely used to dissociate and associate body orientation (proprioception) and spatial localization (exteroception) during ocular motor and eye-hand coordination activities. Most procedures are performed standing; as performance improves, techniques are utilized with the patient actively moving through the room.

SUMMARY AND RECOMMENDATIONS

Myopia progression can be controlled and increases in myopia eliminated with many motivated and compliant patients. Research should be undertaken to document that defined segments of the population can benefit from the approach I have espoused. Until then, perhaps this approach can be implemented in cases in which the case history and analytical tests, consistent with the use-abuse theory, suggest nearpoint stress and subsequent adaptation as etiologic factors.

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