BIFOCAL CONTROL OF MYOPIA*

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ABSTRACT

Forty-three native American bifocal wearers grouped by yearly age levels from 9 to 15 with a mixed group of 6 to 8 year olds are matched on beginning age, sex, beginning refractive error and ending age with 83 Native American control subjects. Similarly 226 Caucasian bifocal wearers are matched on the same criteria against 192 control subjects. Although the comparisons are made on each age group, the average annual rate of progression for the bifocal Native American subjects is -0.12 and -0.10 diopters in the right and left eyes respectively against a comparable rate of progression of -0.38 and -0.36 diopters for the control subjects. These differences are significant but not as significant as those found on the Caucasian subjects of -0.02 and -0.03 diopters right and left eyes against -0.53 and -0.52 diopters for the controls.

A number of investigators have reported successful control of the progression of myopia in children through the use of cycloplegic drops on a daily or alternate day basis.[1-3] The success of the use of cycloplegic drops for the control of myopia is usually believed to be related to the reduction of the accommodative response under cycloplegia. Young[4] has reported similar results on monkeys.

If the reduction of the accommodative response is related to the progression of myopia, it seems reasonable that the reduction of the accommodative response through the use of plus reading glasses or through the use of bifocals on already myopic children should also have the effect of reducing the rate of progression of myopia in children. Such has been reported by a number of investigators.[5-11]

Mandell[12] found no evidence to support the concept of control of myopia progression

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through the use of bifocals. Mandell indicated that what is needed to establish the merits of bifocal control is a study in which bifocals are fitted to one of two groups of myopic patients comparable in age, degree of myopia, rate of progression before correction and environment. Under these conditions the rate of progression of the group given bifocals could then be easily checked against the rate of the control group. He also indicated that a study of this type presents difficult operational procedures due to the problem of obtaining suitable subjects for the necessary length of time.

Since Mandell[12] was not able to carry out such a study he substituted an evaluation of patients in the clinical records of a practicing optometrist and proceeded to violate his own suggested criteria. Thus the patients who were fitted with bifocals had an average initial refractive error of -2.75 diopters with an average initial age of 14.3 years, while his control patients had an average initial refractive error of -1.48 diopters with an average initial age of 17.1 years. Clearly, the subjects who were fitted with bifocals were progressing at a higher rate since they had developed almost twice as much myopia by age 14 as the control subjects had by age 17. Also, since myopia is supposed to more or less stop progressing in the late teens (at the end of high school for individuals who do not go beyond high school) one would expect the 17-year-old subjects to show less progression with or without bifocals than the younger subjects who were wearing bifocals. This lack of matching between the bifocal wearers and the controls makes it difficult to draw conclusions, although Mandell does conclude that the wearing of bifocals had little or no effect on the progression of myopia.

In a major retrospective evaluation of their own practice Roberts and Banford[11] compared the effects of bifocals on progression in juvenile myopia. In their review of the literature they accurately evaluated the studies of Miles[8] and of Mandell[12] and designed their own investigation to take into account the age and sex of their bifocal and control subjects. The population consisted of 226 males and 305 females. All of the children had been refracted at least twice before their 17th birthday and the two refractions were used to determine the mean annual rates of change for both the bifocal and control or single vision lens subjects. For the total population of single vision or control subjects with sexes combined, the mean annual rate of change was found to be -0.401 diopters and for the same combination of bifocal subjects -0.357 diopters. In both groups the girls appeared to progress faster than the boys. There were apparently 396 children in the control group and 85 in the bifocal group. The remaining 50 children apparently were in a third group which consisted of children who wore single vision lenses and bifocals during different portions of the observation period.

When the single vision and bifocal groups[11] are broken down into those who progressed at a rate of greater than 1/8 diopter per year as compared with those who progressed at a rate of less than 1/8 diopter per year, the Chi Square test was significant at the 0.04 level in favor of the bifocal group, progressing at a slower rate than the control group. Roberts and Banford apparently did not match the experimental control subjects in terms of age and beginning refractive error, but rather calculated the correlation coefficients between the annual rate of change and age. Then they used these correlation coefficients to calculate partial coefficients in order to eliminate the effect of age. Their study shows that bifocals appear to have the effect of reducing the rate of myopic progression by 22.8% as compared with the single vision group. They also looked at other variables such as conditions which would determine who should wear a bifocal and how much the add should be.

The present study represents an attempt on the part of the authors to achieve the suggestions made by Mandell[12] in designing a study to determine the effect of bifocals on the progression of myopia and to compare these subjects with same-sex control subjects who demonstrate a similar age and initial refraction and who have been followed for a number of years.

One of the difficulties of carrying on a longitudinal study which requires cooperation over time on the part of the subjects involved in the study is to achieve such cooperation consistently. This is particularly important in attempting to evaluate the effect of such drugs as atropine or devices such as bifocals on the progression of myopia in children. If the drug is not used properly or at all, or if the bifocal is not fit properly or used, the investigator usually assumes that his instructions have been followed. However, without adequate checkups, he may be misled by his subjects.

SUBJECTS

The Native American sample consisted of 156 children ranging in age from 6 to 21 with 54 children in the bifocal group and 102 in the control group. The Caucasian sample consisted of 441 subjects who are divided into 226 bifocal subjects and 215 control subjects with the same age range as the Native American subjects. The samples were approximately half male and half female. Bifocals were recommended for all children; the control group consisted of children who refused or whose parents refused the bifocals.

The subjects in all samples were grouped by ages using the age at which the bifocal subjects began to wear bifocals as the "beginning age" with the control subjects matched to these ages. There were sufficient subjects at all age levels between 9 and 15 inclusive in the Native American and Caucasian populations to form yearly groups as well as a Caucasian group with beginning age 16. The subjects in both groups between the ages of 6 and 8 inclusive were grouped into a mixed group as were the 17 and 18 year old Caucasian subjects to form 8 age groups of Native American subjects and 10 age groups of Caucasian subjects with a bifocal group and a control group at each age level.

The bifocal and control subjects were matched on beginning refractive error as a group as well as on age and sex since other studies have shown that the earlier the child or animal becomes myopic the higher the yearly rate of progression.[13-15] Unfortunately, when the two groups at each age level were matched for beginning refractive error, a number of subjects were lost. For the Native Americans 43 bifocal and 83 control subjects were retained as were 226 Caucasian bifocal and 192 control subjects.

The rates of progression for the not used subjects were similar to the rates for the used subjects within each group. The similarity suggests that no bias was introduced by omitting the subjects for whom matches could not be found.

PROCEDURES

All refractions and prescriptions were performed by the senior author. When a young child was referred for a initial cycloplegic refraction which indicated that the child was in or close to myopia, the author discussed with the parents the possibility of fitting a reading lens or bifocal which would provide 3/4 to 1 diopter (D) of plus lens magnification over the minus distance prescription which was usually undercorrected by 0.50 diopter. For example, if the child's refraction indicated -1.00 diopters, the prescription would be written for -0.50 D with a plus 1.50 diopter add. If the child responded positively to this lens combination, the minus distance correction would be dropped but a reading lens of +1.00 diopter would be retained. In the case of older children who were already myopic more than -2.00 diopter the distance correction would be cut 0.50 diopter and a plus 1.50 to 2.00 diopter add would be prescribed. In all cases a flat top add would be prescribed and positioned so that the top of the add would reach the middle of the pupil when the eyes are in the primary position. This location of the add would require the child to tilt his head slightly forward and to look slightly up to avoid the add at distance but would make it virtually impossible to read without using the add even if the glasses slide downward on the nose as they so frequently do in children.

Virtually all children fitted with bifocals in this study demonstrated a near point esophoria as did most of the control children who were progressing. If the parents did not wish to try the bifocal approach, the child was fitted with a slight undercorrection for distance (0.50 diopters) and told to wear his glasses at all times.

Since the senior author carried out all refractions, there is no inter-investigator variability although there is intra-investigator variability as well as the possibility of bias in favor of the bifocal subjects. Unfortunately, this possibility was ignored until it was too late to meaningfully institute a control for this possibility. Ideally, a second refractionist should have performed initial and final refractions on all subjects without knowledge as to whether the subjects were in the bifocal or control groups. Even though this blind control was not carried out, we did attempt to determine whether bias was present by comparing rates of change, variability and patterns of change with age within and between the bifocal and control groups and between the Native American and Caucasian subjects since the use of the bifocals differed in the two groups.

The average number of cycloplegic refractions during the study for the Native American bifocal and both control groups was 3.2 while for the Caucasian bifocal group the average was 4.1. The beginning levels 7-11 inclusive were followed for an average of 4.0 years, the 12-14 year olds inclusive for 3.1 years, and the 15 and 16 year olds for an average of 2.7 years.

RESULTS

The number of subjects in each group is presented in Table 1 (since the control subjects could be used at different age levels the number of control subjects totals to more than the number of subjects in each sample). The results obtained on the Caucasian subjects are presented in Figure 1. The results for the Native American subjects and for the combined Native American and Caucasian groups are presented in Figure 2.

The mean rate of progression for the Native American bifocal subjects for all age levels is -0.12 diopters for the right eye and -0.10 diopters for the left eye compared with the corresponding values for the Native American control subjects of -0.38 and -0.36 diopters for the right and left eyes respectively. Thus, the annual rate of progression in the bifocal group is one-third or less of the rate of progression in the control subjects. For the Caucasian subjects the annual rate across all age groups is -0.02 diopters for the right eye and -0.03 diopters for the left eye of the bifocal subjects. The control subjects have a mean annual rate of -0.53 for the right eye and -0.52 for the left eye; under these conditions the annual rate of progression for the bifocal subjects is approximately 5 percent (4 percent for right eyes and 6 percent for left eyes) of that shown by the control subjects. The corresponding values for the combined group are -0.04 diopters for each eye in the bifocal group and -0.51 for the right eyes and −0.49 for the left eyes in the control group. The overall annual rate of progression for the bifocal subjects is 8 percent of that demonstrated by the control subjects who were matched against the bifocal subjects on beginning age, sex, beginning refractive error and to some extent on total time.

For ages 6 through 12, except for age 11, the Caucasian control subjects have annual rates of progression ranging between -0.56 D and -0.67 D in either eye while the rates at age 11 are -0.51 D for the right eye and -0.53 D for the left eye. At age 13 the rate drops to -0.49 D and -0.48 D for right and left eyes and continues to drop reaching -0.42 and -0.41 D at age 14, -0.43 and -0.41 D at age 15, -0.38 and -0.39 D at age 16, and finally, -0.24 and -0.28 D for the right and left eyes respectively at age

TABLE I – Number of Subjects at Each Beginning Age Level for Caucasian, Native American, and Combined Caucasian-Native American Bifocal and Control Groups*

Beginning Age Level	Caucasian Bifocal	Caucasian Control	Native American Bifocal	Native American Control	Combined Caucasian-Native American Bifocal	Combined Caucasian-Native American Control
6-8	11	51	5	23	16	74
9	14	41	3	12	17	53
10	25	50	5	9	30	59
11	26	56	6	7	32	63
12	28	63	7	15	35	78
13	44	37	6	16	50	53
14	17	32	4	8	21	40
15	33	25	7	14	40	39
16	18	12			18	19
17	10	16				
Totals	226	383* (192)	43	104* (83)	259	478* (275)

*The actual number of control subjects in each group is given in parentheses after the totals; the values in the control columns represent repeated use of the same subjects at different age levels where refractions are available.

17. If a child is referred for examination at age 8 with 1 diopter of myopia and continues to progress at the average rate for each year until he is 18 he will develop approximately 5 diopters of myopia by the time he reaches 18 years of age. The bifocal subject would fall between 0 and 1.40 D of myopia.

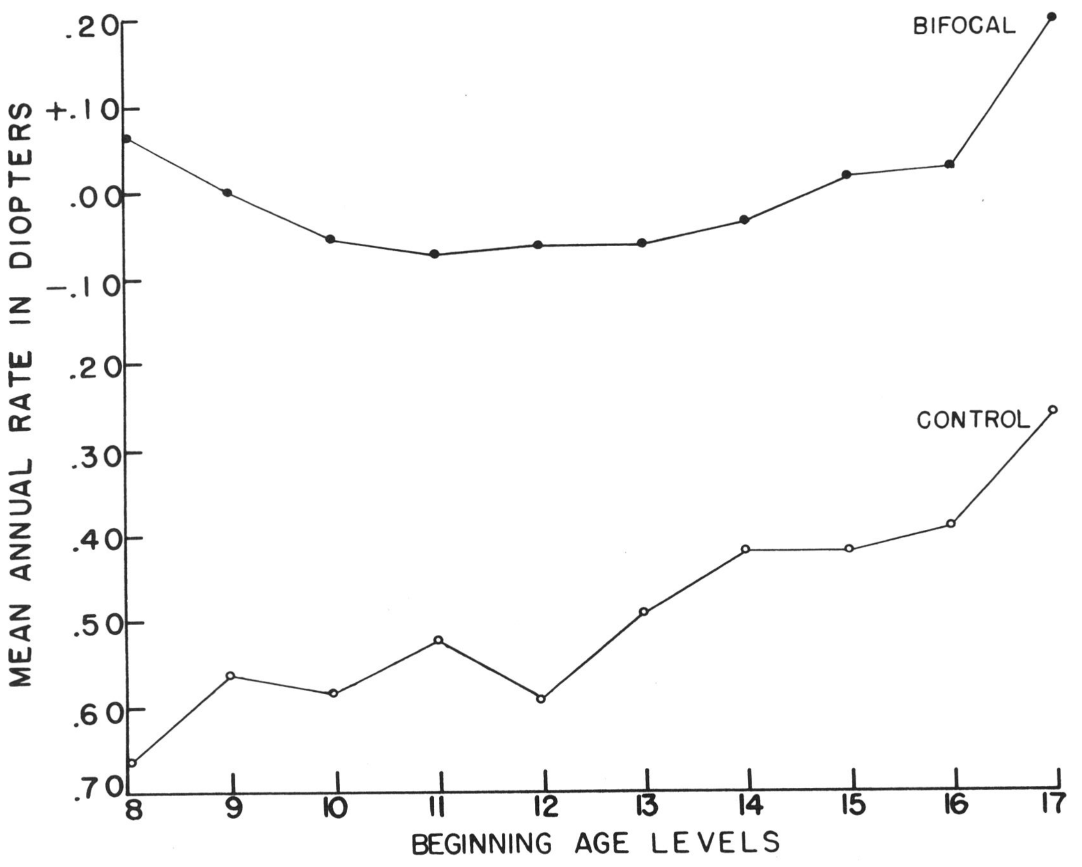
The Native American subjects in the control group vary between -0.37 and -0.46 D for the ages 6 through 12 except for age 11 which jumps to -0.60 D in each eye. At age 13 the annual rate drops to -0.32 D for the right eye and -0.25 D for the left eye. The rate moves up to -0.42 D for each eye at age 14 and then drops to -0.20 D for each eye at age 15.

All differences between bifocal and control Native American subjects below age 13 are significant at least at the 0.05 level, but the differences at ages 13, 14 and 15 are not significant. All differences between bifocal and control groups are significant at the 0.001 level for the Caucasian and the combined Caucasian and Native American groups.

DISCUSSION

The matching criteria employed were ranked in order of importance from beginning age as the most important through beginning refractive error, sex and ending age as the least important. While there are no significant differences between beginning ages, sex or beginning refractive errors in either eye, there are significant differences in ending ages for the Caucasian subjects in age levels 12 and 13. The criterion measure, annual rate of progression, is the quotient or the difference between beginning and ending refractive errors divided by the difference between each subject's beginning and ending ages which ranged between one and sixteen years.

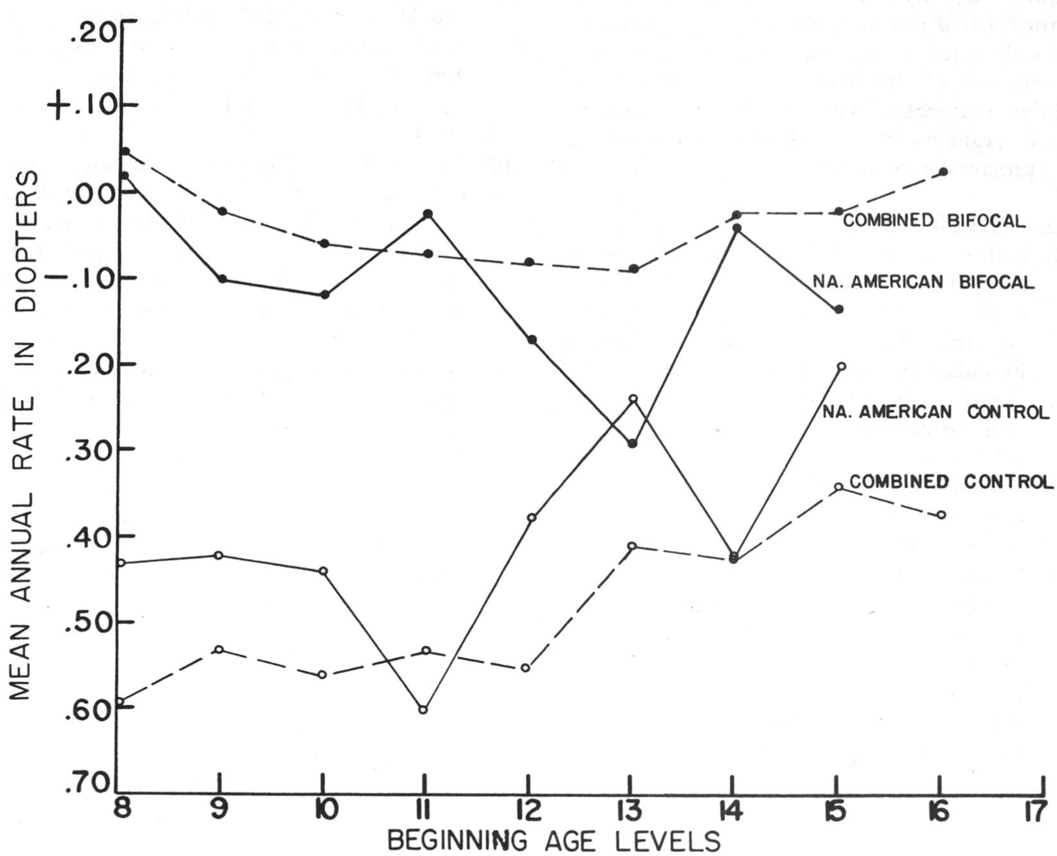
***FIGURE 1:** Comparison of the mean annual rates of myopic progression for the Caucasian bifocal and control groups in terms of beginning age of each group. Age 8 represents the mean of a mixed group of 6, 7 and 8 year olds. (Ns are given in Table 1.)*



The rate of progression in the control groups is higher at the younger ages and drops at the older ages in both the Caucasian and Native American groups although the rate of change in the Native American group is only 2/3 the rate in the Caucasian group. This varying rate is similar to that found by Roberts and Banford[11] in Caucasians. When the two groups are compared in terms of the annual rate of change for the bifocal subjects, the Native American subjects change at an average rate which is 4 to 6 times higher than the rate found in the Caucasian subjects. While the Native American bifocal group changes more rapidly than the Caucasian bifocal subjects, the control subjects change less rapidly than the Caucasian control subjects to reduce the differences between the bifocal and control Native American subjects.

While this difference in pattern may be due to several variables, one variable which operates differentially in this situation is the reading variable. The senior author's twenty-year experience and a six-year longitudinal study of the Native American subjects at Warm Springs, Oregon indicates that the Native American subjects generally read less and less intensively than the Caucasian subjects. They also drop out of school earlier and do not wear their bifocals or regular glasses as compulsively as do the Caucasian subjects. Since the bifocal wearers do not use their bifocals as consistently as the Caucasian subjects, the bifocals should be less effective with these subjects. On the other hand, since the Native American subjects in general do less reading, the control subjects should show lower rates of progression if reading is an important variable. Thus, the reading variable alone could account for the differences found between the two groups. Even under these conditions the bifocals have a significant effect on

FIGURE 2: Comparison of the mean annual rates of myopic progression for the Native American and the combined Native American and Caucasian bifocal and control groups in terms of beginning age of each group. Age 8 represents the mean of a mixed group of 6, 7 and 8 year olds. (Ns are given in Table 1.)



the annual rates of progression and clearly have a more significant effect on the Caucasian subjects who follow instructions better and also do more reading. Bifocals seem to be a relatively effective means of controlling the progression of myopia although probably not as effective as atropine.

The rates of progression of about -0.50 diopters per year among the control subjects at the younger age levels are commonly[1-3,7,8,16,17] found among myopes at these age levels and suggest that the control subjects in this study do not differ from myopic children who are fitted with a virtually full correction which is worn constantly. The annual rate of progression of -0.04 diopters per year found among the bifocal subjects is uncommonly found among myopes at these age levels and suggests that the bifocals are having a controlling and reducing effect upon the rate of progression. The effectiveness of the bifocal in this study may well depend upon the very high position of the add fitted to the child. The bifocal can only have an effect if it is used. The bifocal fitted too low, too small a bifocal, or a bifocal which is not used does not provide a proper test of the effectiveness of the bifocal. Under reasonably well controlled conditions the bifocal appears to be effective in controlling the progression of myopia.

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