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A study to compare two methods of near astigmatism testing

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A study to compare two methods of near astigmatism testing

Abstract

A study to compare two methods of near astigmatism testing

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A STUDY TO COMPARE TWO METHODS
OF NEAR ASTIGMATISM TESTING

(O.D. Thesis)

Submitted to
the Faculty of College of Optometry
Pacific University
Forest Grove, Oregon

by
Herbert A. Blake
James A. Richardson
William W. Shirk

April 21, 1972

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Accepted by the faculty of the College of Optometry, Pacific University, in partial fulfillment of the requirements for the Doctor of Optometry degree.

______________ Director of thesis

______________ Thesis Chairman

We gratefully acknowledge the cooperation and assistance given this paper by the students and faculty of the College of Optometry, Pacific University, with special thanks to Dr. R. Septon.

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Purpose

It is the purpose of this research project to compare the astigmatic component of the human visual system using two different types of astigmatic testing at sixteen inches. One method involved utilizes a near cylinder testing technique devised by Dr. C.B. Pratt of Pacific University, College of Optometry. This method of near astigmatic testing has been well established and is widely used at the College of Optometry, Pacific University. This method is a monocular test. The second method utilizes a binocular testing technique. This method was brought to our attention through a paper written by Dr. Deryck Humphriss on "The HIC Technique". This method involves fogging one eye while testing the other eye but maintaining fusion at all times during the testing. To our knowledge, there has been no literature comparing these two methods.

It is our intention to test each subject using both methods and comparing the results. We are mainly interested in the change in power and axis of the cylinder, if any, and the magnitude of change.

It is our contention that there will be no clinically significant difference in the power between the monocular and binocular methods and no clinically significant difference in cylinder axis.

We will also compare the subjective preference of each subject, whether he was more comfortable and better able to respond to the monocular or binocular method.

Historical Summary

Ever since Thomas Young first described astigmatism, various testing methods developed resulting in both monocular techniques and binocular techniques. Participation in binocular refractive techniques at the clinical level was influenced and stimulated by A.E. Turville. (10) However, the standard procedures of choice in the United States appear to be of the monocular variety, although there are advocates of binocular techniques (Smith (9), Copeland (2), and Humphriss (6) who suggest inaccuracies when astigmatism is determined monocularly under dissociation.

The influence of cyclophoria on the axis of stigmatism is largely ignored by monocular techniques. Miles (7) found an average difference of 8 degrees between binocular and monocular determination. Grolman (4) found a similar difference. Hood, Mees, and Slocum (5) when comparing forty seven subjects concluded no measurable difference between binocular and monocular astigmatic power values measured at far when using the Jackson cross-cylinder technique and the Jackson cross-cylinder technique combined with the H.I.C. technique of fogging. All these studies cited dealt with far point testing.

Humphriss, in an attempt to utilize binocular vision while testing for astigmatism, developed the H.I.C. technique. The following was his hypothesis: "If one eye is slightly blurred, the central cones of the fovea centralis are suspended and then any alteration made in sharpness made to the retinal image is recorded by the unfogged eye."(6) This assumption serves as a basis for one technique used in this study.

The several studies mentioned above compared various far point methods of astigmatic correction. Some utilized the fogging technique, but none could be found incorporating the technique at near point. Carol Pratt, O.D., Ph. D., in 1937 developed what is now referred to as Pratt's Near Cylinder Test. The technique, which will be the monocular component of our comparison, is similar to the four-ball cylinder test at far, (3) but utilizes cross grid targets. The targets and procedures for both tests will be described below.

(6) Humphriss, D., "The Refraction of Binocular Vision", The Opthalmic Optician, Oct. 5, 1963.

PROCEDURE

A near point test to measure the subjective astigmatism was devised by C.B. Pratt of Pacific University. The test consists of a reduced Snellen chart, cross grid chart with lines 180 and 90 degrees, and another cross grid chart with the lines 45 and 135 degrees.

The keratometer was used for an estimate of the amount of corneal cylinder. Javal's rule was then applied to the amount of cylinder found for a more accurate approximation of the total astigmatic correction of the eye. This amount of cylinder was then put in the phoropter.

The subject was then asked to read the 20/20 line of the reduced Snellen chart at 16 inches with normal near point illumination and with Javal's rule in place. Plus lenses were then added before each eye simultaneously until the patient reported he could no longer make out any of the letters. One eye was occluded and the plus was reduced on the eye that was observing the target until the letters in the 20/20 row could just be seen again. This eye was then occluded and the other eye was unoccluded, and plus was then reduced in this eye until the 20/20 row of letters could just be seen. This produces minimal accommodative stimulation and, we assume, response and so minimizes the possibility of subjective changes due to accommodation.

A cross grid chart with lines running 90 and 180 degrees was then placed at the 16 inch distance with normal near point light. One eye was occluded so only one eye was seeing the target. The subject was asked which group of lines, vertical or horizontal, appeared darker than the other group. If the vertical lines appeared darker a minus quarter diopter of cylinder was added with axis 180. The subject was then asked again which group seemed darker. Minus cylinder was added in quarter diopter steps until the subject reported a reversal of the lines. A plus a quarter of sphere was added for every half diopter of minus cylinder that was added to maintain the spherical equivalent.

If cylinder was already present axis 180 and the subject reported that the lines running in the 180 were darker than the lines running at 90 then the cylinder was reduced until the 90 degrees lines appeared darker. A quarter diopter of cylinder was then added in the 180 again. Thus in either case the subject was left with a slight excess of cylinder power, a condition which makes locating the axis of astigmatism more precise in this method of testing.

The other cross grid chart, having lines at 45 and 135 degrees was then viewed by the subject. He was then asked, "Which lines appear darker now, those lines running up and toward the left (135 degrees) or those lines running up and to the right (45 degrees)". The axis of the cylinder was then rocked and set, finally at the midpoint between where one group of lines appeared darker and where the other group appeared darker.

After the axis was established the cross grid chart with lines in the 90 and 180 degrees were again presented to the subject. Minus cylinder power was then reduced until a reversal of the lines was noted by the subject. The sphere was adjusted to maintain spherical equivelancy.

The eye which was then tested was occluded and the other eye was unoccluded. The same procedure was then followed to find the amount and axis of cylinder. The findings were then recorded as the amount of minus cylinder and the axis of the cylinder for both eyes.

After the findings were recorded for the monocular viewing of the test target the sphere was changed back to the original monocular recovery points, and the cylinder was changed back to the power and axis of the net opthalmometer cylinder. Thus the starting conditions for the binocular testing were the same as for the monocular testing sequence.

The same cross grid charts were used for the monocular and binocular testing. A dark circle was drawn around the outside of the cross grid chart to help maintain fusion during binocular exposure. The charts can be seen in appendix B.

In the binocular testing both eyes were unoccluded and plus 0.75 diopters were added to the eye not being tested. Thus the fovea of the tested eye received a clear image and the fovea of the non-tested eye received a blurred image. Both eyes were seeing the whole target and peripheral fusion was maintained by the black ring around the target.

The same procedure was then followed as for the monocular testing sequence. A reversal was found for the 90 - 180 lines. The axis was measured and then the least cylinder power was found again by reversal. These findings were then recorded and the data can be seen in appendix A.

The subject was then asked which method, the monocular or binocular condition, seemed easier in terms of response. Other information taken during the exam was name, age, sex, and which method was tested first, either monocular or binocular.

The first 42 eyes were tested monocularly first, then tested binocularly. The next 36 eyes were tested binocularly first, then monocularly. A random order of testing was then begun to discover if there was any change depending on which test was given first. The total number of eyes tested first monocularly was 54 compared to 50 for binocular.

When considering the procedures used in this study, it should be kept in mind that certain variables were compensated for and others were not. The selection of subjects was based on availability. The subjects were either students or staff of Pacific University, age ranging from 19 years to 34. Some of the variables that were not compensated for were the following: the phoropters used, the exact amount of illumination in the refraction rooms (age of lamp bulbs and wall reflectance factors varied), time of day, and the patient's pre-set, i.e. activity of the patient just prior to testing. One refractionist was used to test all of the subjects to hold variation in testing to a minimum. Also, both the monocular and binocular methods of testing on any one subject was done at the same sitting in the same room to help compensate for the variables surrounding the tests.

Analysis and Results

Our control study involved testing one subject from each power group ten different times to evaluate the fluctuation inherent in the mechanics of running the tests. Three power groups were used to better analyze the data since axis change is related to the magnitude of cylinder power.

The first power group consisted of subjects with 0.25 to 1.00 diopter of astigmatism. The second power group consisted of individuals with 1.25 to 2.00 diopters of astigmatism, and the third group 2.25 to 3.00 diopters of astigmatism.

A control study was done on one individual from each power group to test the variance in testing technique not associated with the astigmatic testing difference between the monocular and binocular method. In groups one and two of the control study there was a random variation of 0.25 diopter and five degree axis change. In group three was a random variation of 0.25 diopter of power and no axis change.

Standard deviations were run on the control study groups with the following results:

	Standard Deviation Power	Standard Deviation Axis
Control group one	.11	2.3
Control group two	.10	2.3
Control group three	.10	0.0

Eighty-nine eyes qualified under power group one. Of these, fifty-six showed no change in power and thirty gave a change of 0.25 diopter, with three giving a change of more than 0.25 diopter. Eleven eyes fell under power group two. Of these, seven showed no change, three showed 0.25 diopter change and one gave a change of more than 0.25 diopter. The total in power group three consisted of four eyes. Three of these showed no power change and one gave 0.25 diopter change.

The axis change in group one of eighty-nine eyes, showed sixty with no change in axis, eighteen with change of five degrees, and eleven with a greater than five degree axis change.

Group two consisted of four eyes with no change, five with five degree change and two with a greater than five degree change.

Group three consisted of two eyes with no change, one eye with a five degree change and one eye with a greater than five degree change.

Appendix A gives a summary of the subject data in graphical and tabular form.

Control group one, two and three gave standard deviations of approximately .12 diopter of cylinder power. Axis change in groups one and two was approximately two degrees standard deviation, and the third group zero degrees .

On a statistical significant level of one standard deviation, all changes of 0.25 diopter or more were significant changes. All axis changes of five degrees or more were also significant under this same criteria of one standard deviation of significance level.

Of group one, thirty eyes showed a change of two standard deviations, three a change of five standard deviations, and fifty-six less than one standard deviation in cylinder power. Of this same group, axis changes of two standard deviations were found in eighteen eyes, greater than two standard deviations in eleven eyes, and less than one standard deviation in sixty eyes. Of group two, three eyes showed a change of two standard deviations, one a change of five standard deviations, and seven less than one standard deviations in cylinder power. The axis change in group two showed five eyes of two standard deviations, two eyes of greater than two standard deviations, and forty eyes of less than one standard deviation. Group three showed one eye of two standard deviations, and three eyes of less than one standard deviation of cylinder power. Axis change of this group showed two eyes of significant change, and two eyes of no significant change.

In power group one, thirty-three eyes gave a significant change in power, and twenty-nine a significant change in axis out of a total number of eighty-nine eyes in this group. Power group two showed four eyes of significant change in power and seven a significant change in axis out of the total of eleven. In power group three one showed a significant change in power, and two showed a significant change in axis out of a total of four eyes.

The criteria for significant change in the above evaluation is based on the statistical standard deviation. A clinically significant deviation is of necessity greater than the statistical deviations due to the testing technique. The data taken was measured to the nearest .25 diopter. As a result, optometric significance could not be less than .25 diopter, and on a statistical basis, two standard deviations.

On the above clinical definition of significance, only four eyes of the total one hundred four were clinically significant.

All four of these eyes gave a cylinder power of 1.25 diopter or less.

The testing technique of axis findings involved recording the axis to the nearest multiple of five. As a result, optometric significance could not be less than five degrees, and on a statistical basis, two standard deviations. With this clinical definition of significance, only fourteen eyes showed a clinically significant change in axis. All but three were of .75 diopter or less of cylinder power. The remaining three ranged from 2.25 to 1.25 diopter.

In the control study of group three, there was no variation in axis. Of the subjects in group three, two gave no change in cylinder axis when comparing the two methods. One subject revealed a five degree change and one a fifteen degree change. These changes in axis were in a random direction, that is to say there was no consistant direction of change in axis.

Some studies such as Borish have eluded to the fact that binocular conditions tend to position the eyes in an excyclotorsional direction from the monocular position. This did not occur in our study consitantly and may be explained in the fact that our fusional controls were designed for perpheral vision. Therefore the fusional targets used did not provide for central fusion under binocular conditions.

Of all the groups, nineteen subjects reported no difference in the case of responding to the two different tests. Thirteen subjects reported the binocular test to be easier. Twenty subjects preferred the monocular method. Data indicates no decisive trend for preference of one method of testing over the other in the age group of eighteen to forty years.

SUMMARY

For the clinical situation, resolving astigmatic error in a range of 0.25D to 2.25D, this study suggests no practical difference in results between binocular and monocular near point testing methods. Whether of low (0.25D) or moderately high (2.00D) astigmatic error, the vast majority of data suggests that any power or axis variance between the two methods is clinically insignificant based upon the control study. It should be noted that it would be desirable to have more subjects in group three.

The results of this study suggest a freedom of choice in selecting either binocular or monocular astigmatic testing methods with an assurance of equal clinical accuracy. Parameters such as time, practitioner preference, and ease of patient response could be used as test method criteria without sacrificing validity of results.

Any further studies in this area may be better served by more stringent control. Better controlled illumination, target design, equipment used, testing technique and use of finer scaled axis and power units might be desirable in getting more precise data. However, our study is representative of normal clinical testing in that no standardization of the above listed parameters has been established.

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APPENDIX A

TABLE I

NUMBER OF EYES IN EACH CATAGORY AND POWER GROUP

Number of Eyes Tested	Amount of Cylinder Power					
	0.25 1.00		1.25 2.00		2.25 3.00	
	B	M	B	M	B	M
104	72	70	10	14	4	5

TABLE II

DIFFERENCE BETWEEN MONOCULAR AND BINOCULAR TESTS IN TERMS OF AXIS CHANGE AND POWER CHANGE

Difference between Monocular and Binocular tests					
Change of Axis (degrees)			Change of Power (diopters)		
0-5	6-10	10+	0.00	0.25	0.25+
67	23	14	67	33	4

TABLE III

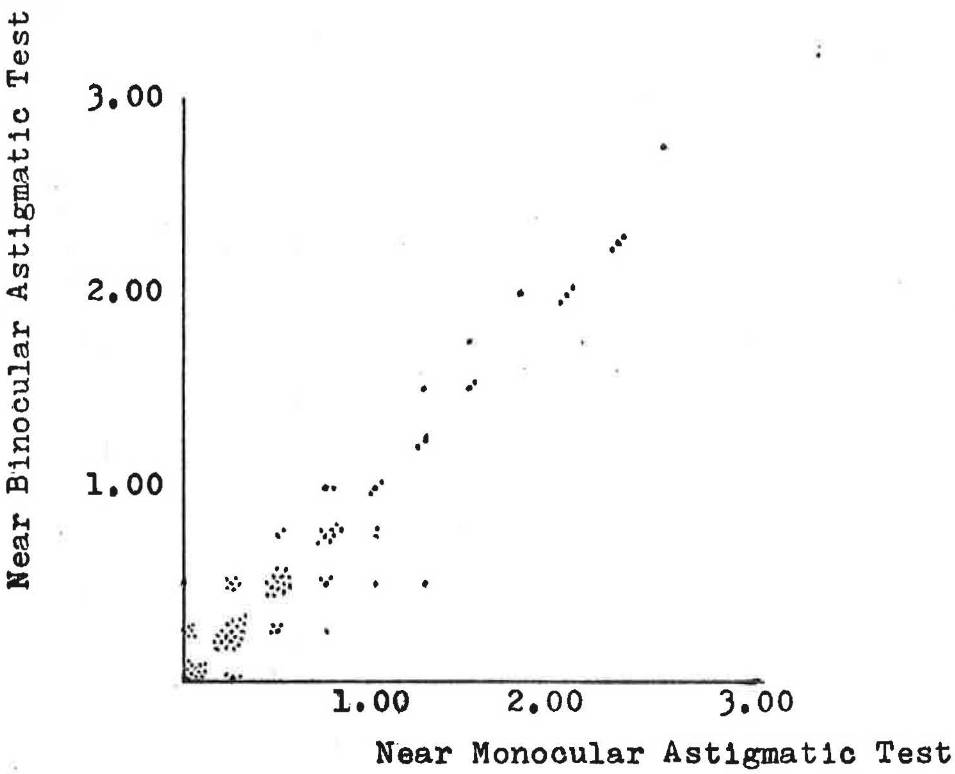
NUMBER OF SUBJECTS IN EACH TEST PREFERENCE

Method Tested First B (Bin.) M (Mon.)		Test Preference		
B	M	Both Test Same	Binocular Easier	Monocular Easier
50	54	19	13	20

GRAPH I

SCATTERGRAM SHOWING POWER CHANGE

OF MONOCULAR VS. BINOCULAR TESTING



GRAPH II

SCATTERGRAM SHOWING CYLINDER AXIS CHANGE

OF MONOCULAR VS. BINOCULAR TTESTING

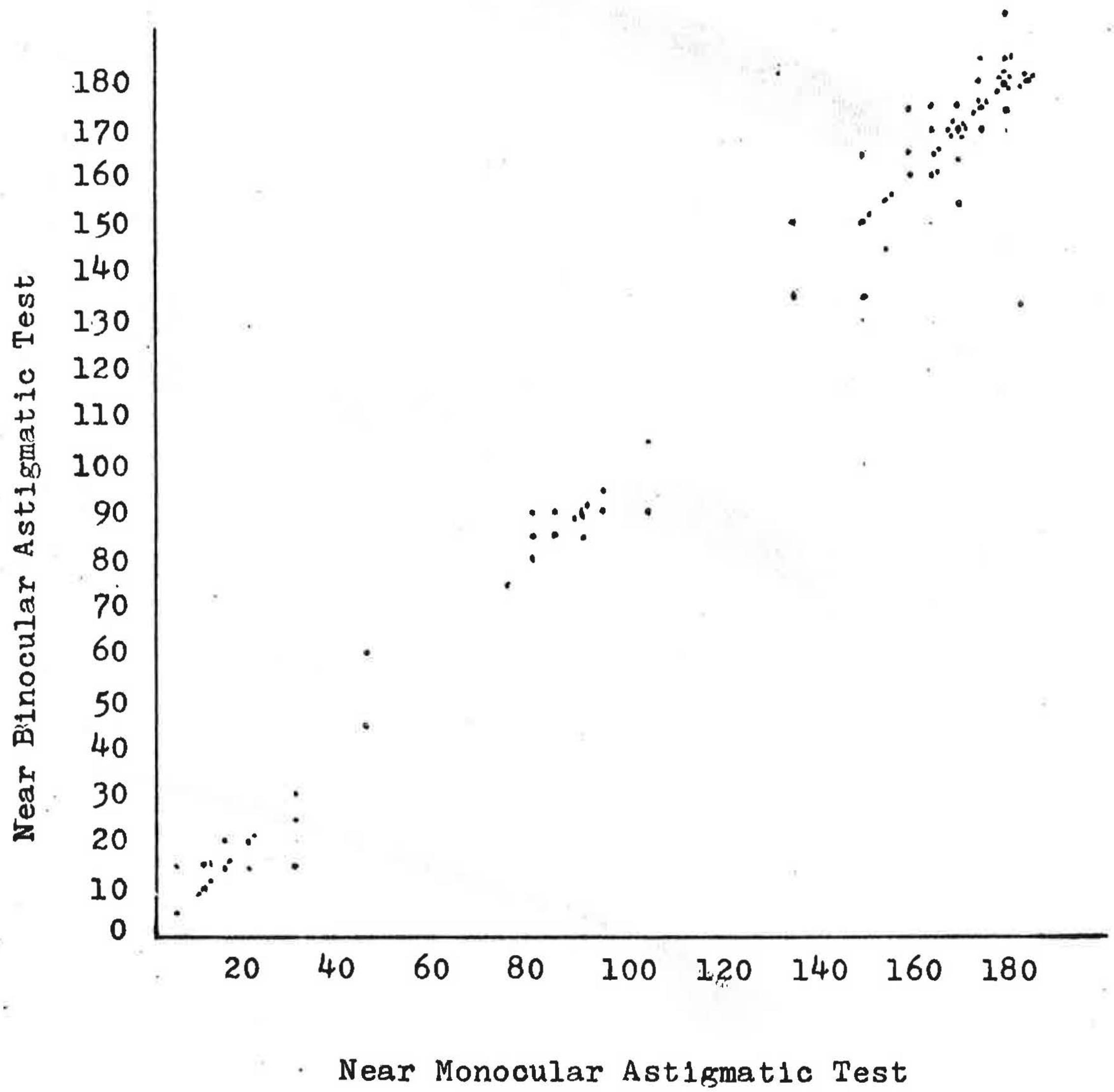


TABLE IV

NUMBER OF EYES SHOWING CHANGE IN POWER IN EACH POWER GROUP

No Change	56	7	3
.25 D Change	30	3	1
.50 D Change	3	1	--
Total	89	11	4

TABLE V

NUMBER OF EYES SHOWING CHANGE

IN AXIS IN EACH POWER GROUP

No Change	60	40	2
5° Change	18	5	1
>5° Change	11	2	1
Total	89	11	4

APPENDIX B

CONTROLLED STUDY DATA

Power Group I

H.B. Male Age 29

Trial	Tested First	Keratometer	21_m (B/R)	Mon. Cyl.	Bin. Cyl.
1	M	-.50x90	+150/125	0.25x10	0.25x5
		-.12x90	+125/75	----	---
2	M	-.50x90	+150/125	0.50x5	0.50x5
		-.50x90	+150/100	0.25x180	0.25x5
3	M	-.50x90	+175/150	0.25x10	0.25x15
		-.12x90	+150/100	----	----
4	M	-.50x90	+100/75	0.25x15	0.25x10
		-.50x180	+100/75	---	---
5	B	-.50x90	+125/75	0.25x10	0.25x10
		-.87x90	+125/75	----	----
6	M	-.50x90	+125/75	0.25x5	0.50x10
		-.87x90	+125/75	----	----
7	B	-1.12x90	+125/100	0.50x10	0.25x5
		-.87x90	+125/75	0.25x180	---
8	B	-.50x90	+150/125	0.25x5	0.25x5
		-.62x90	+175/125	----	----
9	M	-.50x90	+175/100	0.25x5	0.25x8
		-.50x90	+175/75	----	----
10	M	-.37x90	+150/100	0.25x5	0.50x8
		-.50x90	+125/75	0.25x10	0.25x10

CONTROLLED STUDY DATA

Power Group II

J.S. Male Age 26

Trial	Tested First	Keratometer	21m (B/R)	Mon. Cyl.	Bin. Cyl.
1	M	39.75/41.25@90 39.87/40.50@90	+.25/pl +.25/-.25	-1.75x180 -1.25x8	-2.00x180 -1.25x10
2	B	39.75/41.50@90 40.00/41.00@90	+.25/pl +.25/-.25	-1.75x5 -1.25x6	-2.00x5 -1.25x180
3	B	39.75/41.25@90 40.00/41.00@90	+.25/pl +.25/-.25	-2.00x180 -1.25x5	-2.00x180 -1.25x180
4	B	39.75/41.14@90 40.00/41.25@90	+.25/pl +.25/-.25	-2.00x180 -1.25x5	-2.00x5 -1.25x180
5	B	39.75/41.50@90 40.00/40.87@90	+.25/pl +.25/-.25	-2.00x5 -1.50x5	-1.75x180 -1.25x180
6	M	39.75/41.25@90 40.00/41.00@90	+.25/-.25 pl/-.25	-1.75x5 -1.50x175	-1.75x5 -1.50x180
7	M	40.00/41.25@90 40.00/41.00@90	+.25/-.25 +.25/-.25	-1.75x5 -1.50x5	-1.75x180 -1.25x5
8	M	39.75/41.12@90 40.12/41.00@90	+.25/-.25 +.25/-.25	-1.75x5 -1.50x180	-2.00x180 -1.25x10
9	M	39.75/41.12@90 40.25/41.00@90	+.25/-.25 +.25/-.25	-1.75x5 -1.25x5	-1.75x180 -1.50x180
10	B	40.00/44.50@90 40.00/41.75@90	+.25/pl +.25/-.25	-1.50x180 -1.50x5	-1.75x180 -1.50x15

CONTROLLED STUDY DATA

Power Group III

E.S. Male Age 34

Trial	Tested First	Keratometer	21m (B/R)	Mon. Cyl.	Bin. Cyl.
1	M	41.25/43.50@90	+1.25/+.50	-2.25x180	-2.25x180
		41.00/43.50@90	+1.25/+.50	-2.50x180	-2.50x180
2	M	41.25/43.50@90	+1.50/+.50	-2.25x180	-2.25x180
		41.00/43.50@90	+1.50/+.75	-2.50x180	-2.50x180
3	B	41.25/43.50@90	+1.50/+.50	-2.25x180	-2.25x180
		41.00/43.50@90	+1.50/+.75	-2.50x180	-2.50x180
4	B	41.50/43.75@90	+.75/+.25	-2.25x180	-2.25x180
		41.00/43.75@90	+1.00/+.50	-2.75x180	-2.50x180
5	B	41.50/43.75@90	+1.00/+.50	-2.50x180	-2.25x180
		41.00/43.75@90	+1.25/+.50	-2.75x180	-2.75x180
6	B	41.50/43.75@90	+1.00/+.50	-2.50x180	-2.25x180
		41.00/43.87@90	+1.00/+.50	-2.75x180	-2.75x178
7	M	41.50/43.87@90	+1.00/+.25	-2.50x180	-2.25x180
		41.00/43.75@90	+1.00/+.50	-2.75x180	-2.75x180
8	M	41.50/43.75@90	+1.00/+.25	-2.50x180	-2.25x180
		41.00/43.75@90	+1.00/+.50	-3.00x180	-2.75x180
9	B	41.62/43.62@90	+1.00/+.25	-2.50x180	-2.25x180
		41.00/43.75@90	+1.00/+.50	-2.75x180	-2.75x180
10	M	41.50/43.75@90	+1.00/+.25	-2.50x180	-2.25x180
		41.00/43.75@90	+1.00/+.50	-2.50x180	-2.75x180

RAW DATA

Subj.	Sex	Age	Keratometry	Mon. Cyl.	Binoc. Cyl.	Pwr. M-B	Ax. (dif)	Subj. Pref.
1. P.D.	M	23	43.00/44.00@90	-.25x10	Sph.	-.25	-	M
			42.25/44.00@90	-.50x160	-.25x175	-.25	15	
2. D.S.	M	22	41.75/42.25@90	Sph.	Sph.	-	-	M
			42.00/42.25@90	Sph.	Sph.	-	-	
3. E.N.	M	25	42.75/42.50@90	-.25x180	-.25x05	-	5	M
			42.87/43.25@90	-.25x165	-.50x160	+.25	5	
4. E.M.	M	23	41.87/42.00@90	-.25x20	-.50x20	-.25	-	B
			42.00/42.50@90	-.25x150	-.50x135	-.25	15	
5. D.T.	M	22	42.50/42.00@90	-.25x170	-.25x155	-	15	M
			41.87/41.50@90	-.25x170	-.25x170	-	-	
6. L.P.	M	27	44.00/43.75@90	-.25x155	-.50x145	+.25	10	N
			43.50/43.50@90	-.25x180	-.25x180	-	-	
7. J.Z.	M	24	44.50/45.00@90	-.25x165	-.25x165	-	-	B
			44.75/45.75@90	-.50x05	-.50x05	-	-	
8. G.P.	M	26	41.00/42.50@90	-.75x20	-.75x15	-	5	N
			41.00/43.75@90	-2.00x170	-2.00x175	-	5	
9. D.R.	M	25	40.00/40.62@90	-.25x05	-.25x180	-	5	B
			40.25/41.75@90	-.25x180	-.25x180	-	-	
10. J.R.	M	22	43.37/42.75@90	-.75x105	-.25x90	-.50	15	M
			42.75/43.00@90	-.50x45	-.50x45	-	-	
11. G.B.	M	22	45.00/42.25@90	-.50x180	-.50x175	-	5	N
			45.25/45.75@90	Sph.	Sph.	-	-	
12. C.S.	M	22	44.00/44.00@90	-.25x180	-.25x180	-	-	N
			44.00/44.00@90	-.25x180	-.25x15	-	15	
13. E.D.	M	40	42.00/42.50@90	-.50x90	-.50x90	-	-	N
			41.00/41.75@90	-.25x80	-.25x90	-	10	
14. B.W.	M	24	42.87/42.87@90	-.25x150	-.25x150	-	-	N
			42.50/43.00@90	-.50x15	-.50x15	-	-	
15. D.B.	M	29	40.87/42.50@90	Sph.	Sph.	-	-	N
			40.87/42.50@90	-2.25x30	-2.25x15	-	15	

Subj.	Sex	Age	Keratometry	Mon. Cyl.	Binoc. Cyl.	Pwr. M-B	Ax. (dif)	Subj. Pref.
16. D.R.	M	23	42.87/43.50@90	-.50x30	-.50x30	-	-	M
			43.00/44.00@90	-.75x170	-.75x170	-	-	
17. I.S.	M	34	41.25/43.50@90	-2.25x180	-2.25x180	-	-	B
			40.87/43.87@90	-2.50x175	-2.75x180	+.25	5	
18. R.S.	M	25	42.75/44.00@90	-.75x175	-.75x175	-	-	M
			42.75/44.25@90	-1.50x175	-1.50x175	-	-	
19. D.K.	M	28	43.25/42.75@90	-1.25x105	-1.25x105	-	-	M
			43.00/43.00@90	-.75x90	-1.00x90	+25	-	
20. J.O.	M	25	41.75/42.50@90	-.25x155	-.25x155	-	-	N
			41.75/42.50@90	-.25x10	-.25x10	-	-	
21. L.L.	M	26	42.00/42.75@90	-.75x170	-.75x165	-	5	N
			42.00/42.25@90	Sph.	Sph.	-	-	
22. G.I.	M	25	42.87/43.25@90	-.50x135	-.50x135	-	-	N
			43.50/43.62@90	-.25x75	-.50x75	+.25	-	
23. T.S.	M	27	46.25/47.50@75	-1.25x150	-.75x165	-.50	15	N
			46.12/47.50@95	-1.00x45	-.75x60	-.25	15	
24. D.C.	M	23	44.00/44.75@90	-.25x90	Sph.	-.25	-	N
			44.00/44.75@90	Sph.	-.25x80	+.25	-	
25. B.M.	M	24	43.50/44.75@90	-1.00x20	-1.00x20	-	-	B
			43.25/44.75@90	-.75x170	-.75x170	-	-	
26. P.	M	24	43.00/44.75@90	-.50x135	-.50x150	-	15	B
			43.50/44.25@90	Sph.	-.25x75	+25	-	
27. M.R.	M	22	44.00/44.50@90	-.25x90	-.50x85	+.25	05	M
			43.75/44.50@100	Sph.	-.50x85	+.50	-	
28. B.P.	M	25	44.00/45.25@90	Sph	-.25x05	+.25	-	M
			43.50/45.75@90	-.50x10	-.25x10	-.25	-	
29. L.F.	M	26	42.25/42.50@90	Sph.	-.25x05	+.25	-	B
			42.50/43.25@90	-.50x10	-.25x10	+.25	-	
30. D.B.	M	23	44.00/45.50@90	-.75x155	-.50x155	-.25	-	B
			43.75/45.00@90	-1.00x10	-.50x15	-.50	05	
31. G.D.	M	23	41.25/41.75@90	-.25x20	Sph.	-.25	-	N
			41.50/42.50@90	-.25x160	-.25x160	-	-	

Subj.	Sex	Age	Keratometry	Mon. Cyl.	Binoc. Cyl.	Pwr. M-B	Ax. (dif)	Subj. Pref.
32. R.B.	M	25	41.25/42.25@90	-.75x165	-.75x165	-	-	N
			41.50/42.00@90	-.25x20	Sph.	-.25	-	
33. R.P.	M	25	43.50/44.75@90	-1.25x05	-1.50x180	+.25	05	M
			44.00/44.50@90	Sph.	Sph.	-	-	
34. R.B.	M	27	43.00/43.00@90	-.25x85	-.25x85	-	-	N
			43.00/43.00	Sph.	Sph.	-	-	
35. D.H.	M	25	44.00/44.00@90	-.25x90	-.25x90	-	-	N
			44.00/44.50@90	-.25x180	-.25x180	-	-	
36. J.S.	M	26	40.00/41.50@90	-1.50x180	-1.75x180	+.25	-	M
			40.00/41.75@90	-1.50x05	-1.50x15	-	10	
37. B.D.	M	26	43.50/45.37@90	-1.75x15	-2.00x20	+.25	-	B
			43.00/44.75@90	-2.25x175	-2.25x.75	-	-	
38. D.R.	M	24	44.50/44.25@90	Sph.	-.25x180	+.25	-	M
			44.50/44.25@90	-.50x85	-.50x90	-	05	
39. C.R.	M	35	42.50/42.00@90	-.75x80	-1.00x85	+.25	05	N
			42.25/41.75@90	-.75x95	-.75x95	-	-	
40. J.B.	M	25	42.75/44.00@90	Sph.	Sph.	-	-	B
			43.50/44.00@90	Sph.	Sph.	-	-	
41. J.O.	M	25	41.00/42.00@90	-.75x170	-.50x170	-.25	-	M
			41.00/42.75@90	-.75x165	-.50x170	-.25	05	
42. G.G.	M	22	44.50/45.87@70	-1.00x160	-1.00x165	-	05	N
			44.25/45.50@90	-1.25x05	-1.25x180	-	05	
43. C.B.	M	23	43.87/44.50@90	Sph.	Sph.	-	-	B
			43.25/44.50@90	-.50x05	-.50x180	-	05	
44. A.S.	M	23	45.87/45.25@90	-1.00x95	-1.00x90	-	05	M
			46.00/45.75@90	-1.00x80	-.25x80	-25	-	
45. K.B.	F	21	45.50/45.75@90	-.50x10	-.50x15	-	05	M
			45.75/45.50@90	-.50x175	-.75x05	+.25	10	
46. S.S.	F	18	44.00/44.00@90	Sph.	Sph.	-	-	B
			44.00/44.00@90	-.25x10	Sph.	-.25	-	
47. J.P.	F	23	41.50/42.50@90	-.75x170	-.75x170	-	-	M
			41.75/42.25@90	-.25x165	-.25x175	-	10	

Subj.	Sex	Age	Keratometry	Mon. Cyl.	Binoc. Cyl.	Pwr. M-B	Ax. (dif)	Subj. Pref.
48. D.M.	M	24	39.12/40.75@90	-2.00x180	-2.00x05	-	05	M
			38.75/40.50@90	-2.00x175	-2.00x175	-	-	
49. A.S.	M	25	44.75/45.00@90	-.50x175	-.75x170	+.25	05	M
			44.37/45.00@90	-.50x170	-.50x170	-	-	
50. B.P.	M	22	44.75/46.25@90	Sph.	Sph.	-	-	M
			44.74/46.25@90	-.50x150	-.50x150	-	-	
51. M.M.	M	28	42.50/44.00@90	-.50x165	-.50x160	-	05	B
			42.75/44.00@90	-.50x30	-.25x25	-.25	05	
52. H.P.	M	25	42.75/44.00@90	-.25x170	-.25x170	-	-	N
			42.75/44.00@90	-.25x15	-.25x15	-	-	

ACTUAL SIZE COPY OF TARGETS USED