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A statistical evaluation of data for the study of the influence of physical variables of a contact lens upon the centering of the lens on the cornea

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Abstract
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A STATISTICAL EVALUATION OF DATA FOR THE STUDY OF THE INFLUENCE OF PHYSICAL VARIABLES OF A CONTACT LENS UPON THE CENTERING OF THE LENS ON THE CORNEA

A SPECIAL PROBLEM DONE FOR DOCTOR CHARLES B. MARGACH
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INTRODUCTION

This paper is a continuation of a fifth year optometry thesis entitled "The Study of Physical Variables of a Contact Lens and its Effect Upon the Centering of the Lens on the Cornea" (actually that paper was concerned with the development of a photographic technique to measure centering aspects of a contact lens on the cornea and the gathering of data using that technique). 1

The lenses used in the study were divided into two main groups:

Group A

The diameter was 9.2mm for all lenses and the radius of curvature of the peripheral curve was varied in the following seven steps:

1. 9.00mm
2. 9.50mm
3. 10.00mm
4. 10.50mm
5. 11.00mm
6. 11.50mm
7. 12.25mm

Group B

The radius of curvature of the peripheral curve was held constant at 12.25mm and the diameter was varied in the following eight steps:

1. 10.2mm
2. 10.0mm
3. 9.8mm
4. 9.6mm
5. 9.4mm
6. 9.2mm
7. 9.0mm
8. 8.8mm

THE PROBLEM

The problem was to re-evaluate the data compiled in the above mentioned thesis. In the original thesis the conclusion was that the photographic technique gave reliable results. The reliability of the results must be qualified (see p-3). Statistical methods were to be used to determine whether the changes in radius of curvature of the peripheral curve (p-curve) mentioned above and changes in diameter mentioned above had any influence upon the centering of the lens on the cornea.

THE STATISTICAL EVALUATION

a) Grouping the data

The data were grouped as to p-curve changes (Group A) and diameter changes (Group B). Each group was subdivided into left and right eyes, which were in turn divided into centering scores for vertical and horizontal deviations from the center of the pupil.

b) Reliability of the photographic technique of measuring centering

Two pictures of each lens were taken and centering scores for each were obtained. The product moment correlation coefficients were calculated for the centering scores for the pairs of pictures as subdivided above. The correlation coefficients are given in Table 1.

In the original paper the lowest valued r was subjected to an r to Z transformation to establish confidence limits. The lower confidence limit was tested for significance with the t test. The t was significant at the 0.01 level, which simply means that the obtained r was not due to variable errors of sampling. 4

	r
Group A (p-curve)	
Right eye	
Vertical	.7166
Horizontal	.95283*
Left eye	
Vertical	.82408
Horizontal	.56578
Group B (Diameter)	
Right eye	
Vertical	.7819
Horizontal	.69141
Left eye	
Vertical	.78305
Horizontal	.99755**

Table 1. Correlation coefficients for all pairs of centering scores. The group for which the r value is noted with a single asterisk will be referred to as Group X and the group for which the r value is noted with a double asterisk will be referred to as Group Y.

The r value can be interpreted as a test of reliability of the photographic technique. 2,3,4 In general, however, the r value must be 0.90 or greater before individual predictions can be made. 4 Unless the r value is high enough to make individual predictions, the variability in centering scores induced by the photographic technique is apt to "mask" any changes in centering induced by the changes in diameter or p-curve. Hence only Groups X and Y from Table 1 were subjected to an analysis of variance.

c) Evaluation of the data for Group X

The two centering scores for each lens were combined and a mean score calculated (see pp 42-3 of the original paper). This mean centering score was then used to represent each lens for each subject.

These data were then subjected to a Treatments by Subjects analysis of variance. Table 2.

Source	df	ss	ms
Treatments (A)	7	111.2	15.9
Subjects (S)	8	296.7	37.1
Treatments by Subjects (AS)	54	650.4	12.1
Total	69	958.3	

Table 2. The summary table for analysis of variance of the data for Group X. df, ss, and ms represent degrees of freedom, sum of squares and mean squares respectively.

The ratio of the mean square for treatments (ms A) and mean square for treatments by subjects (ms AS) is distributed as F and constitutes a test of significance of the treatment means. The assumption was that there was no difference in treatment means. The analysis shows that this assumption could not be rejected at the 5% level.

The ratio of the ms S and ms AS is a test of significance of the differences between subject means. The assumption was that there was no difference between subject means. The analysis shows that this assumption could not be rejected at the 5% level but could be rejected at the 10% level.

d) <u>Discussion of the results for Group X</u>

As the treatment means as a group were not significantly different, individual treatment means could not be tested for significance. However, in an analysis of the type used in this paper the significance of the treatment means can be masked by too small a difference between treatments. If three treatments had been used instead of 7, the treatment means probably would have been significant. This could be generalized as indicating that small changes in the radius of curvature have little effect on centering, but larger changes have a small but significant effect. This generalization can not be extrapolated to a population, however, as it is only a

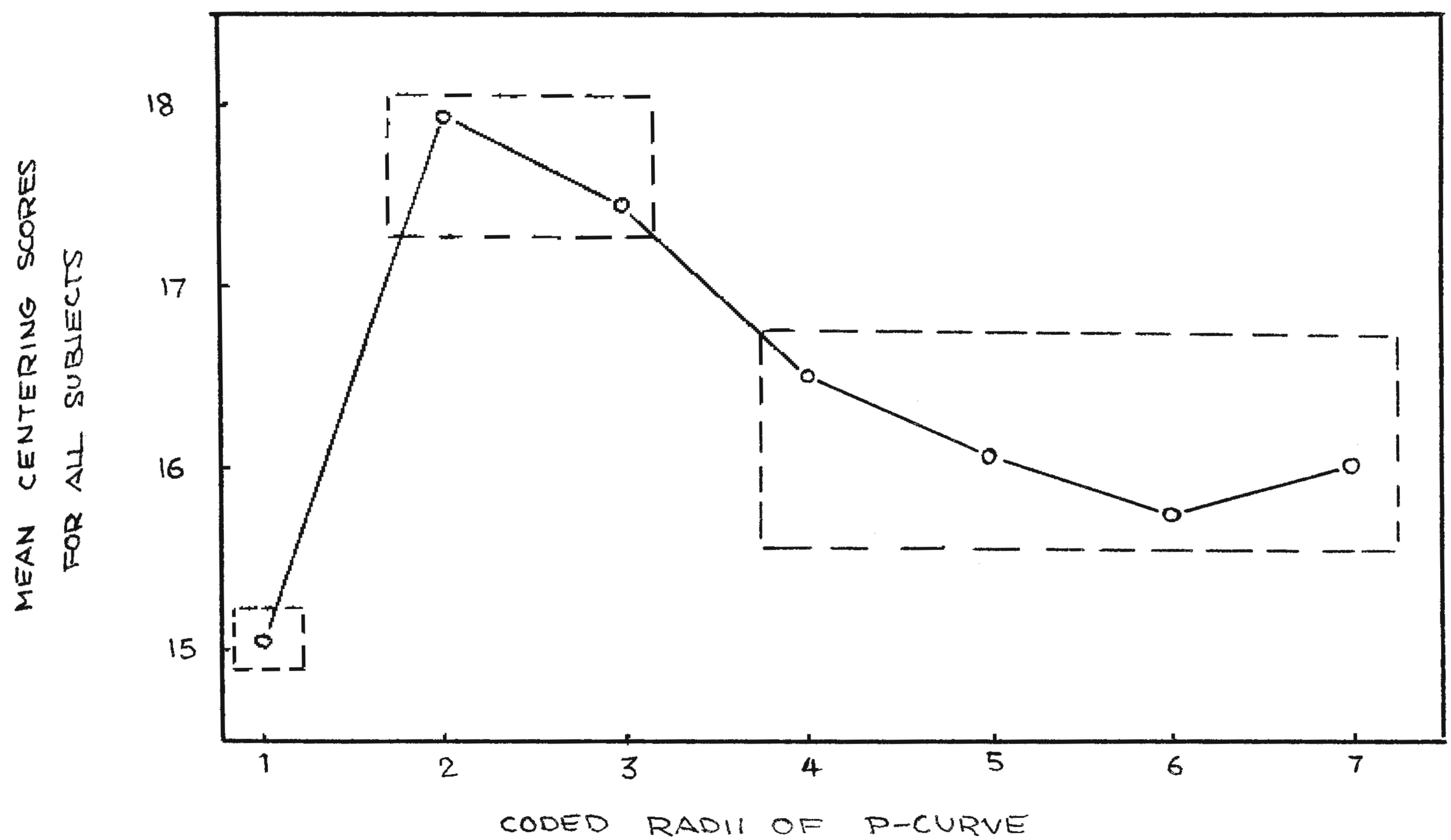

Fig. 1. Mean centering scores for all subjects for each p-curve radius. The abscissa represents the coded p-curve radii and the ordinate the mean centering score for all subjects. The dashed rectangles enclose means that are similar in value.

trend and should be used only to guide further research.

The differences in subject means was not significant but the probability of this occuring by chance was sufficiently small to indicate a trend. Traditionally this is seldom tested, as subject differendes are simply assumed and accepted.

All treatment means were graphed as in Fig. 1 and grouping of the means is noted. This grouping is an arbitrary division of the means into three levels in which the means are relatively the same. One lens from each level could then be used to represent that level. (i.e., lenses 1, 3 and 6). This would reduce the number of lenses necessary for any future research.

e) Evaluation of the data for Group Y

The two centering scores for each lens were combined and a mean score calculated. This mean centering score was then used to represent each lens for each subject.

The data were then subjected to a Treatments by Subjects analysis of variance. Table 3.

Source	df	ss	ms
Treatments (A)	6	52.9	8.62
Subjects (S)	9	389.5	43.2
Treatments by Subjects (AS)	52	746.2	14.3
Total	67	1188.6	

Table 3. The summary table for Treatments by Subjects analysis of varance for Group Y. df. ss, and ms represent degrees of freedom, sum of squares and mean squares respectively.

The ratio of the ms A and ms AS was used to test the differences in treatment means. The assumption was that there was no difference between treatment means. The analysis shows that the assumption could not be rejected at the 5% level.

The ratio of the ms S and ms AS was used to test the significance of the differences between subject means. The assumption that there was no difference between the means could not be rejected at the 5% level.

f) Discussion of results for Group Y

The differences in treatment means probably would have been significant if three treatment levels had been used rather than eight. The differences in means are "masked" when the treatments are too similar. Fig. 2 shows all treatment means which can be grouped into three levels also. In future studies one lens might be used to represent each group (i.e., lenses 2, 5, and 8).

DISCUSSION OF RESULTS FOR GROUPS X AND Y

Variances are additive and in general the total variance of a distribution of scores can be broken down into component variances. 2,3,4 The total variance for both Group X and Y was very high. For both groups the variance attributable to treatments and subjects only accounted for roughly 30% of the total variance. The

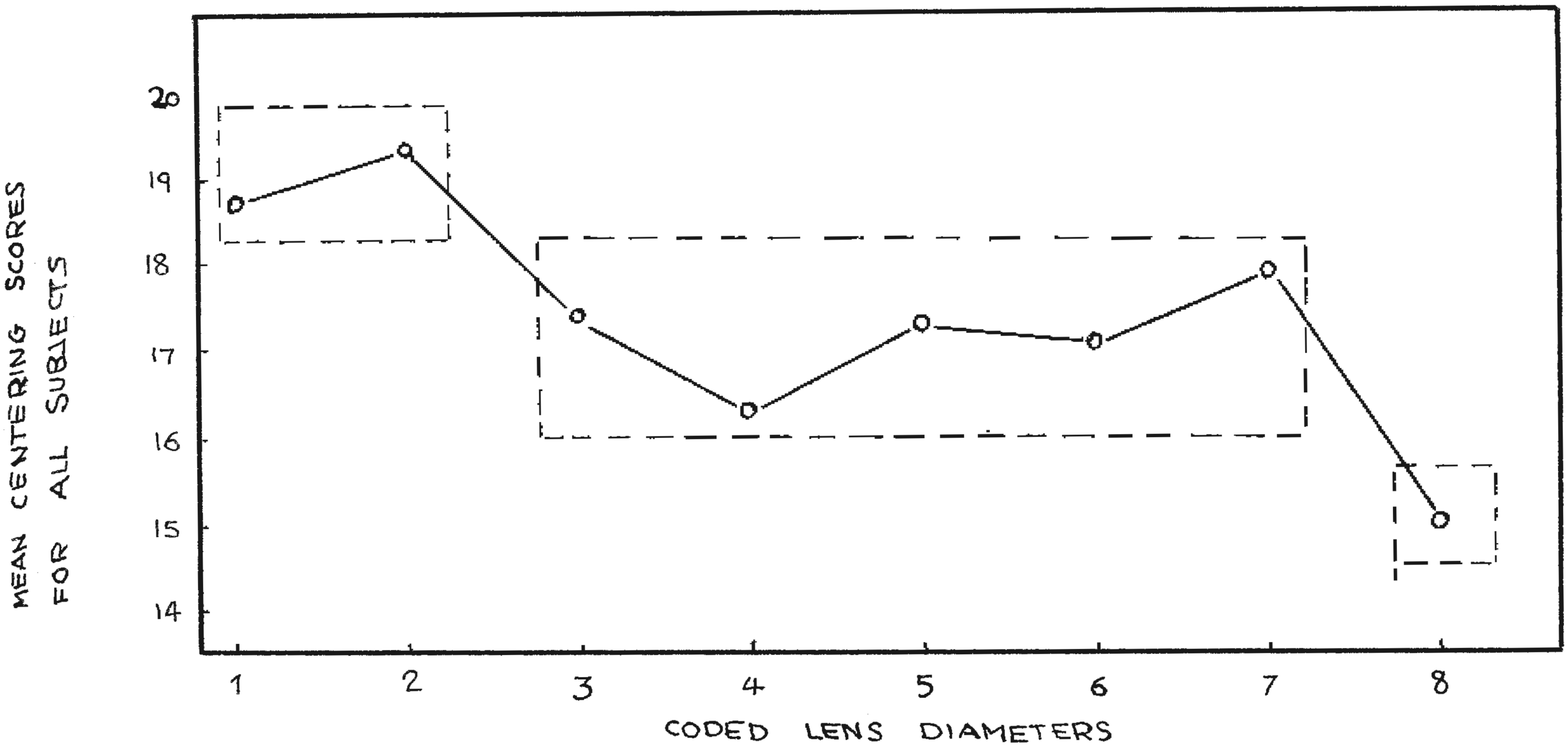

Fig. 2. Mean centering scores for all subjects for each lens diameter. The abscissa represents the coded lens diameters and the ordinate the mean centering score for all subjects. The dashed rectangles enclose means that are similar in value.

remainder of the variance was the ms AS which is known as the residual variance or interaction. (Interaction is used here only in the statistical sense and does not imply any physical attribute.) This high residual variance could not be further analyzed with an experimental design of the type used in the original study. If it could be analyzed it is probable that this variance would be designated interaction of p-curve by diameter. The residual variance constituted approximately 70% of the total variance and it is easy to see that an experimental design should be applied that permits further analysis.

SUGGESTIONS FOR FURTHER RESEARCH

a) Photographic technique

The photography technique should be refined until the correlation, between centering scores for pairs of pictures, is 0.90 or higher for vertical and horizontal deviations.

1. A fixation point should be used. One was not used in the last study as the camera was only a few inches from the eye and blocked almost all of the visual field. Hence, a telephoto lens should be used so that the camera could be several feet from the eye. This would also eliminate tearing and subsequent loosening of the lens caused by the focusing light coming too near the eye.

2. One person should take all pictures.

3. To ensure that there are no corneal changes from wearing a given lens, "K"-readings should be taken after each lens is worn. This would eliminate any "sequence" effect.

Black and white negatives should be used rather than color. This would reduce film and developing costs by approximately 90%.

b) A proposed experimental design

An experiment designed for an ABCD analysis of variance should be used. This is the ONLY way to isolate the influence of each variable and isolate the interaction between any two or three variables.

On the basis of the results of the work in this paper, the author would recommend the following combinations of lens variables:

Radius of p-curve

9.00mm
10.00mm
11.50mm

Diameter

10.00mm
9.4mm
8.8mm

Base curve

Same as flattest central "K"
.50D steeper
.50D flatter

Subjects

five S's with corneal cylinder
between zero and .75D

This would require a total of 135 pairs of lenses, but the total variance could be broken down into the following components:

1. ms p-curve
2. ms diameter
3. ms base curve
4. ms subjects
5. ms p-curve by diameter
6. ms p-curve by base curve
7. ms p-curve by subjects
8. ms diameter by base curve
9. ms diameter by subjects
10. ms p-curve by diameter by base curve by subjects
11. ms p-curve by diameter by base curve
12. ms diameter by base curve by subject
13. ms p-curve by diameter by subject
14. ms p-curve by base curve by subject
15. ms base curve by subjects

If a three way analysis of variance were used (subjects, diameter and p-curve radius), mean squares for only numbers 1, 2, 4, 5, 7, 9, 13 could be designated. Hence, the efficiency of the experiment is greatly increased by adding one more variable.

SUMMARY

Data from a fifth year optometry thesis on a study of physical variables of a contact lens and their effect on the centering of the lens on the cornea, were statistically analyzed. The physical variables of the contact lens used in the original study were as follows: Group A, the diameter was held constant and the radius of curvature of the peripheral curve was changed in seven steps. Group B, the radius of the peripheral curve was held constant and the diameter was changed in eight steps.

The data for each of the above groups was subdivided into left and right eyes, and again for horizontal and vertical deviations from the center of the pupil.

For each lens two pictures were taken and centering scores for the lenses determined. All pairs of centering scores were subjected to analysis by the product moment correlation coefficient. The correlation coefficient was interpreted as a "measure" of reliability of the photographic technique. Only two groups had sufficiently high coefficients to allow individual predictions. Group X, data for horizontal deviations for the right eye for Group A., and Group Y, data for horizontal deviations for the left eye for Group B.

Mean centering scores were calculated for all lenses in both groups. Each group was subjected to a Treatments by Subjects analysis of Variance and the ratio of the mean squares was tested for significance. The assumption that there was no difference between subject means and the assumption that there was no difference between treatment means could not be rejected at the 5% level for either group. However the differences were sufficiently close to being significant that possible trends could be established in the data.

It was proposed that significant differences could be found if only three treatment groups were used, i.e. a low, medium and high value diameter and radius of curvature of the p-curve.

It was shown that only 30% of the total variance could be attributed to the treatments and subjects. The other 70% was a residual for which the components could not be isolated. It was proposed that this residual might be designated interaction of the diameter by the radius of the p-curve. If this were in fact the case, 70% of the variance could be designated interaction of p-curve by diameter.

It was suggested that further research should be done to refine the photographic technique of measuring centering. An experimental design was proposed to enable the total variance to be broken down into all components by using a four way analysis of variance.

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