Article • A Basic Clinical Unit Applicable to Myopic and Non-Myopic Individuals

Carol B. Pratt, PhD, OD • Pacific University College of Optometry • Forest Grove, Oregon

Introduction by David A. Goss and Scott E. Pike

This previously unpublished paper describes the derivation of an interesting and useful refractive metric by Carol B. Pratt (1908-1984). Pratt received a B.S. degree from Willamette University, a PhD in biophysics from the University of Minnesota, where he worked with Charles Sheard, and an OD from the North Pacific College of Optometry. He practiced optometry in Portland, Oregon from 1936 to the mid-1970s and was on the faculty of Pacific University College of Optometry from 1945 to 1974. Pratt based this paper on a 1956 presentation and distributed it to his students.

Pratt developed an innovative and effective optometric examination, which featured near testing before distance testing. The near testing included a test for astigmatism, often called the Pratt near cylinder test by his students,[1-3] and extensive testing of accommodation and convergence. Tests D and E described in this paper were part of his near testing, and they, along with his near astigmatism test, made it possible to make a good prediction of the distance refraction before distance testing was done. Tests D and E conducted at near, and tests A, B, and C conducted at distance, were used to calculate the refractive unit described in this paper. The symbol used for the unit, P, standing for Pacific University, was suggested by one of Pratt's faculty colleagues. Because five tests were used to calculate P, it can be viewed as a potentially highly reliable metric.

Pratt used the P unit as a starting point for measuring accommodation and as a metric for studying longitudinal refractive changes in his patients. Pratt did not publish his testing procedures, his unique analysis method for accommodation and convergence function, or his refractive studies, but he described them to his students, and they have been summarized in a 2023 book.[4]

References

1. Adams RL, Kadet TS, White DM. Comparative study of four-ball cylinder test, Jackson cross-cylinder test, and near cylinder test. J Am Optom Assoc 1966;37:547-9.
2. Graf LO, Weaver JC. A clinical comparison of three astigmatic tests. O.D. thesis, Pacific University, 1987.
3. Johnson BL, Edwards JS, Goss DA, Penisten DK, Fulk GW. A comparison of three subjective tests for astigmatism and their inter-examiner reliabilities. J Am Optom Assoc 1996;67:590-8.
4. Goss DA, Pike SE. Carol B. Pratt: Pacific University's Original Optometric Genius. Forest Grove, OR: Bee Tree Books, 2023.

Musings on Dr. Pratt by Eric Hussey

I grew up watching my father do optometry. He was proud and passionate about what he called "functional optometry," what today has become "behavioral optometry." The idea of "functional" was that he (we) was looking at the various physiological functions involved in vision that produced, either efficiently or inefficiently, the stable—or unstable—visual sensation and perception that we label, simply, "vision."

I also got to talk with my father about how we needed to have more research done on functional optometry. What we do as behavioral optometrists for vision and reading problems was often a target for what he said we needed research on. We just needed more research on what functional optometrists were doing, and the locus of activity in functional optometry was, and is, the clinic. This paints a picture of the interest in, and, in my view, the need for clinical research. Enter Carol Pratt, PhD, OD. He was using, and accumulating data from, a routine vision examination sequence that started at near, and after near data was taken, shifted to distance testing with accommodation relaxed from the near testing.

Dr. Pratt was just retiring from his professorship at Pacific University College of Optometry as I arrived. So, I only actually heard one short discussion from him, this one about his mind-bending technique for testing for aniseikonia. He had measured and calculated all the size effects of the lens powers, adjusted for vertex distance, in his Greens Refractor (phoropter) so he could measure image size changes using a stereo card and a septum at near. Very impressive, especially for a student to hear.

Fortunately, after he retired, other professors explained his basic test techniques. We were given the option of learning Pratt's test sequence that we called the "near exam," but we had to record the data in the normal 21-point exam sequence so advisors could read it. Sometime in all that, someone quoted (misquoted?) Skeffington as saying if he had it to do over again, he would have started exam routines at near.

The advantage of Pratt's techniques starts with efficiency. Very quickly, you are learning how accommodation and convergence are working for the patient. Beyond that, as the attached paper explains, near findings can be used to calculate the distance refractive status—a number Pratt referred to as "P" for Pacific. For example, starting with a monocular negative relative accommodation (OEP #21 - monocularly), subtracting 2.75 diopters from the #21m recovery yields one calculation of P, the distance refractive status. That immediately aids my thoughts in examining a school-age child about whether low plus might be acceptable both at distance and at near, sort of plus acceptance at distance. Maybe the school glasses could be worn full time. Just one more information bit, very quickly and very easily accessible in an absolutely routine examination format—and routine examination is where population statistics come from. Imagine trying to diagnose diabetes as an entity in the population if no one ever took blood sugar readings in people without diabetes. Where would the standards come from?

Which then leads into Pratt as the clinical researcher. Read the attached paper and notice that this represents the data distillation from 1800 examinations in his private practice (his practice separate from Pacific University). This is spectacular. We all need to realize that our practices are small one-by-one research laboratories. We learn from each patient. What Pratt did was accumulate 1800 one-by-one examinations, then digest the data from those to produce a calculation for distance refractive error from a number of different subtests. Brilliant.

Pratt did other clinical investigations, such as the aniseikonia testing. The paper we offer here is all we have that Pratt himself wrote on this aspect of his work. Read it and determine how you can use this information in your practice, but then also, how you might do the same with data in your practice. If you have interest in discussing the full examination routine, at least as I work through the subtests routinely, then contact OEPF (line.vreven@oepf.org), and a time can be arranged to do that. Otherwise, just read this paper, watch the webinar, and consider buying and reading the book, Carol B. Pratt, Pacific University's Original Optometric Genius.

The Original Article by Dr. Pratt

In grouping data from a series of 1800 refractive examinations from my practice during the years 1941-45, with a series of later date in which there were minor changes in technique, an apparently simple relationship between five of the routine measurements common to each series seemed evident. All the measurements were obtained in terms of diopters of lens powers in a Greens' phoropter with a lens plane 2 cm from the cornea and were under conditions of binocular fixation with previously determined astigmatic and anisometropic factors included; the magnitude of the binocular vergence (parallactic angle) to the observed field was maintained between 0 and 3 prism diopters for these five measurements.

The measurements are defined as follows:

A. The Red-green at distance

The "in-phoropter" lens powers, O.D. and O.S., through which equal blackness and distinctness, or reversal of the direction of inequality, was observed by a subject viewing a field of "20/40" black letters, two on a red background and two on a green background as projected by a Clason projector at 5 meters.

B. The "blur-in" at distance

The "in-phoropter" lens of greatest plus power through which the subject accurately reported two-thirds or more of the "20/20" letters as projected by the Clason at 5 meters after the subject had been viewing larger letters through greater magnitudes of plus at this distance.

C. The cross cylinder at distance

The "in-phoropter" lens power through which there was reported equal blackness and distinctness, or a reversal of the direction of inequality, of the lines of a field, the right half of which was composed of eight black lines parallel to one axis of an interposed cross-cylinder of +/-0.50 D and the left half composed of lines perpendicular to those of the right and parallel to the opposite axis of the cross cylinder, all being projected by a Clason at 5 meters distance, and the measurement being made immediately following A.

D. The cross cylinder at 16 inches through 16 prism diopters base-in

The "in-phoropter" lens power through which the subject reported equal blackness or reversal for ten black lines of 0.1 mm thickness and 1.5 mm separation, on a white card located 40 cm from the cornea, five of the lines being perpendicular to the other five and again each group parallel to the respective + and − axes of a +/-0.50 D cross cylinder. An average amount of eight prism diopters of base-in prism was introduced in the rotary prisms 3 cm in front of each lens plane of the phoropter during this measurement, which was preceded by the following measurement.

E. The blur-out at 16 inches through 16 prism diopters base-in

The "in-phoropter" lens power of least plus value through which the subject reported inability to determine accurately any one of eight letters of "reduced 20/20" size on a card at 16 inches when plus lens power was increased from one with which the letters were clearly seen. Again eight prism diopters was placed before each eye during this measurement.

In instances A, C, and D, reversal of observed phenomena at two successive lens values was recorded as the intermediate one-eighth diopter between these lenses. Illumination of the test cards at 16 inches was 20 ft. candles.

The relationships which seemed to exist between these five measurements are indicated in the upper part of Table 1; in dioptric units they were:

$$A = B - 0.50 = C + 0.25 = D - 2.00 = E - 3.25$$

The Greens' phoropter is essentially an additive series of quarter diopter units of lens power; the use of quarter diopter units to express the above relation may as well be used:

$$A = B - 2 = C + 1 = D - 8 = E - 13$$

The dioptric vergence of light from a plane viewed at 16 inches differs from that from a plane at 5 m by 2.30 D, or 2.25 D to the nearest quarter diopter. In order to deliver to the eyes medial stimuli of equal physical dioptric magnitude from these two planes, it is necessary to use +2.25 D, or +9 quarter diopter units, more lens power in the phoropter when viewing the plane at 16 inches. Separating this "working distance" correction from the other lens powers in the observed relationships gives:

$$A = B - 2 = C + 1 = (D - 9) + 1 = (E - 9) - 4$$

The method chosen to examine these relations experimentally was to define a lens quantity P as the average of the five apparently equal observed lens quantities; i.e.,

$$P = (A + B - 2 + C + 1 + D - 9 + 1 + E - 9 - 4) / 5$$

Then, if gross observations were accurate, it would be expected that

$$P = A = B - 2 = C + 1 = (D - 9) + 1 = (E - 9) - 4$$

The records of seventy non-myopic individuals were chosen from clinical files of 1941 to 1955. Each person had been refractively examined at least four times in an interval varying from four to eight years. The records represented five groups of fourteen cases each for each individual, of which there were four refractions over the respective age intervals of 8-12 years, 13-17 years, 18-25 years, 24-31 years, and 30-37 years. This amounted to 280 separate examinations on 70 individuals.

The records of seventy myopic individuals were also chosen on a similar basis, giving five groups over similar age intervals. The quantity P was calculated for each of the refractions in the two populations, i.e., 560.

Figure 1 in the left column shows the distributions of the differences of A, B, C, D, and E, respectively, from P for the 560 individual measurements. The myopic half is shown in dotted distribution, the non-myopic in broken lines, and the total 560 in the solid enclosing figure. The right column represents distributions of the differences of the average calculated P for the 140 persons from the respective average A, B, C, D, and E values. The means and the sigma values for each distribution are given in the central column.

The data shows only minor and quantitatively insignificant differences between the myopic and non-myopic populations. The mode of each frequency distribution of differences was found at the expected magnitude, the curves are fairly symmetrical, and the sigma values are found to be from 0.7 to 1.1 quarter diopters, being least for the cross cylinder at distance and greatest for the measurements at 16 inches. The means and their sigma values are given in Table 1, which also shows that these measurements on the average vary from the predicted values by from 0.02 to 0.06 D.

Table 1. Relationships of Measurements A, B, C, D, and E to Each Other and to P.
(A, red-green at 5 m; B, "blur-in" at 5 m; C, cross cylinder at 5 m; D, cross cylinder at 16 inches with 16Δ BI; E, plus to blur-out at 16 inches with 16Δ BI; P, lens quantity averaging A, B, C, D, and E to represent patients' refractive characteristics)

Gross observation in diopters:

$$A = B - 0.50 = C + 0.25 = D - 2.00 = E - 3.25$$

Or in quarter diopters:

$$A = B - 2 = C + 1 = D - 8 = E - 13$$

Including difference in "working distance":

$$A = B - 2 = C + 1 = (D - 9) + 1 = (E - 9) - 4$$

P calculated in quarter diopters:

$$P = (A + B - 2 + C + 1\ D - 9 + 1 + E - 9 - 4) / 5$$

Then expect in quarter diopters:

$$P = A = B - 2 = C + 1 = (D - 9) + 1 = (E - 9) - 4$$

Differences found in quarter diopters:

	P – A	P – B	P – C	P – (D – 9)	P – (E – 9)	Average
Expected	0	–2	+1	+1	–4	
Means, non-myopes	+0.2	–2.2	+0.9	+1.2	–3.7	
Means, myopes	0.0	–2.1	+0.9	+1.3	–3.9	
Sigma, non-myopes	1.0, 0.6	0.9, 0.8	0.6, 0.4	1.1, 0.9	1.1, 0.9	
Sigma, myopes	0.9, 0.6	1.0, 0.7	0.6, 0.6	1.0, 0.9	1.2, 0.9	
Ave. total difference	+0.1	–2.2	+0.9	+1.25	–3.8	
Sigma, 560 exams	0.9	0.9	0.7	1.0	1.1	0.9 (0.230 D)
Sigma, 140 individuals	0.6	0.7	0.5	0.9	0.8	0.7 (0.180 D)

So, in quarter diopters:

$$P = A + 0.1 = B - 2.2 = C + 0.09 = D - 9 + 1.25 = E - 9 - 3.8$$

Or in diopters:

$$P = A + 0.02 = B - 0.55 = C + 0.23 = D - 2.25 + 0.31 = E - 2.25 - 0.95$$

Difference from gross observation:

A: 0.02 D; B: 0.05 D; C: 0.02 D; D: 0.06 D; E: 0.05 D

Therefore, for calculation of P in diopters:

$$P = (A + 0.02 + B - 0.55 + C + 0.23 + D - 1.94 + E - 3.20) / 5$$

Or rounded to nearest quarter diopter:

$$P = (A + B - 0.50 + C + 0.25 + D - 2.00 + E - 3.25) / 5$$

The original observed relationships between these five refractive measurements then seems quite accurate.

The averaged lens value P may be considered as one located at a 2 cm spectacle plane which delivers a comparable medial dioptric stimulus to the eyes of each individual such that certain specific responses to certain distal stimuli of reversible character are probable. More frequently than any other lens and with a sigma variation less than one-quarter diopter, the binocular lens P is that through which observation of a distal bichrome target at 5 m as described in A is reported equally black and distinct in the two colored fields. More frequently than any other, a lens one-half diopter greater than P is that through which an individual reports a threshold "blur in" observation as described in B. Again more frequently than any other, a lens one-quarter diopter less plus than P is that through which equal blackness or reversal is reported by an individual viewing two sets of perpendicularly arranged lines at 5 m through a cross cylinder, as described in C, and also similarly arranged lines at 16 inches, as described in D when viewed through lenses and prisms compensating for the respective dioptric and binocular vergence differences of this target distance. Finally, more frequently than any other, a lens one diopter greater than P is that through which a "blur out" of letters is reported by an observer viewing a card at 16 inches, as described in E when lenses and prisms again compensate the specific vergence differences of this distance of observation.

The calculated value P for an individual is the average of five real measurements plus constants. The inter-related distributions of differences of these five show a sigma value for each of somewhat less than one-quarter diopter. The sigma of the mean of a

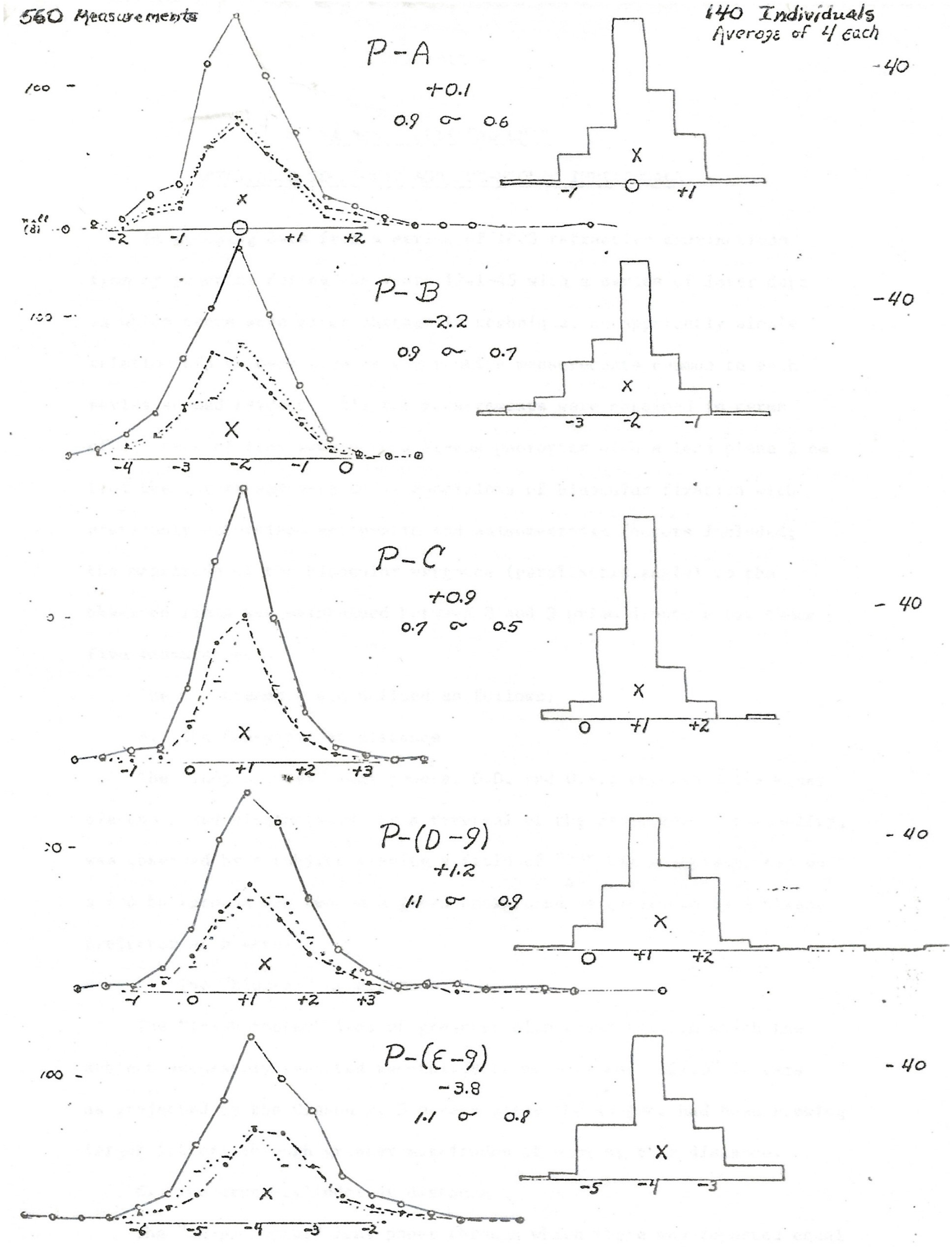

Figure 1. Frequency distributions of the differences of A, B, C, D, and E from P, expressed in quarter-diopter units, on the left for the 560 examinations, and on the right for the 140 individuals from their test findings averaged across their four examinations. The x-axis position of the x on each distribution indicates the mean for each.

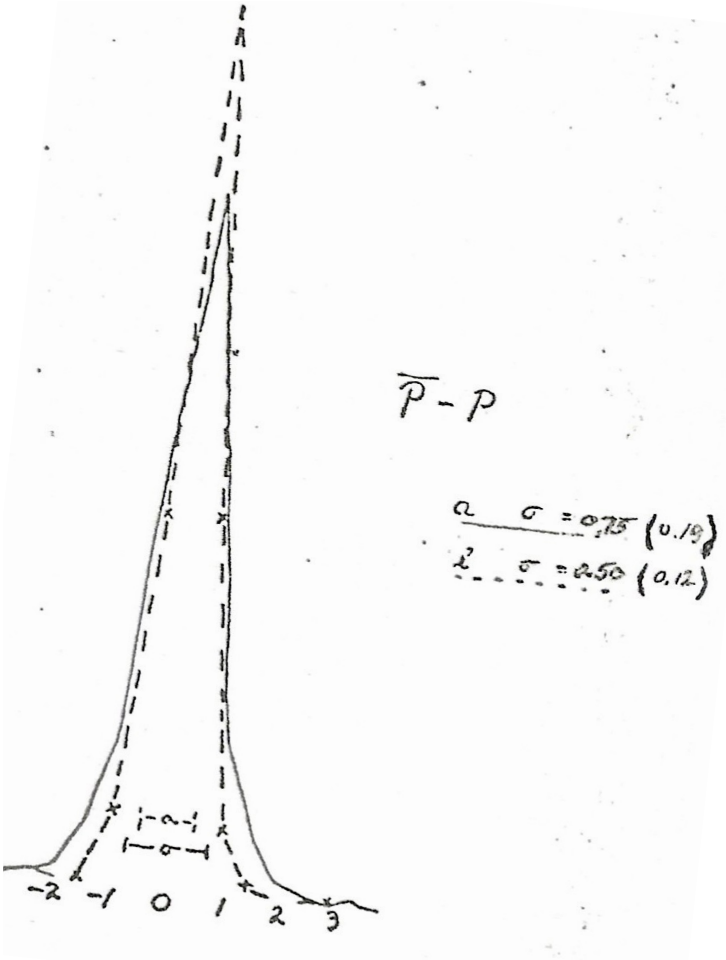

Figure 2. Frequency distributions of the differences of each of the P values from the four examinations of the 70 non-myopic individuals from the average P values of each, expressed in quarter-diopter units, the solid curve assuming no change in P and the dotted curve assuming regular change.

standard distribution curve is calculated to be (1/√n) x the sigma of the distribution curve itself. If the distributions presented here can be considered as reasonably approximate to a standard curve, then the sigma of P may be calculated as (1/√5) x the average sigma of the curves, that is approximately ½ of one-quarter diopter, or one-eighth of a diopter.

Taking the 70 non-myopic individuals for which there are four examinations over an average period of five to six years, and assuming the refractive value P did not change over these periods, the differences of each of the four P values for each person from the average P for each were calculated and represented in a distribution curve as shown in Figure 2 in solid line. The calculated sigma for this distribution of 280 units using an (n – 1) of 210, is 0.75 quarter diopter units (0.19 D). However, when it is assumed that any variation in the value P with time for these individuals is a regular change, that is, to use the best straight line, rather than a horizontal line, as the average value for P with time, the same distribution of differences from

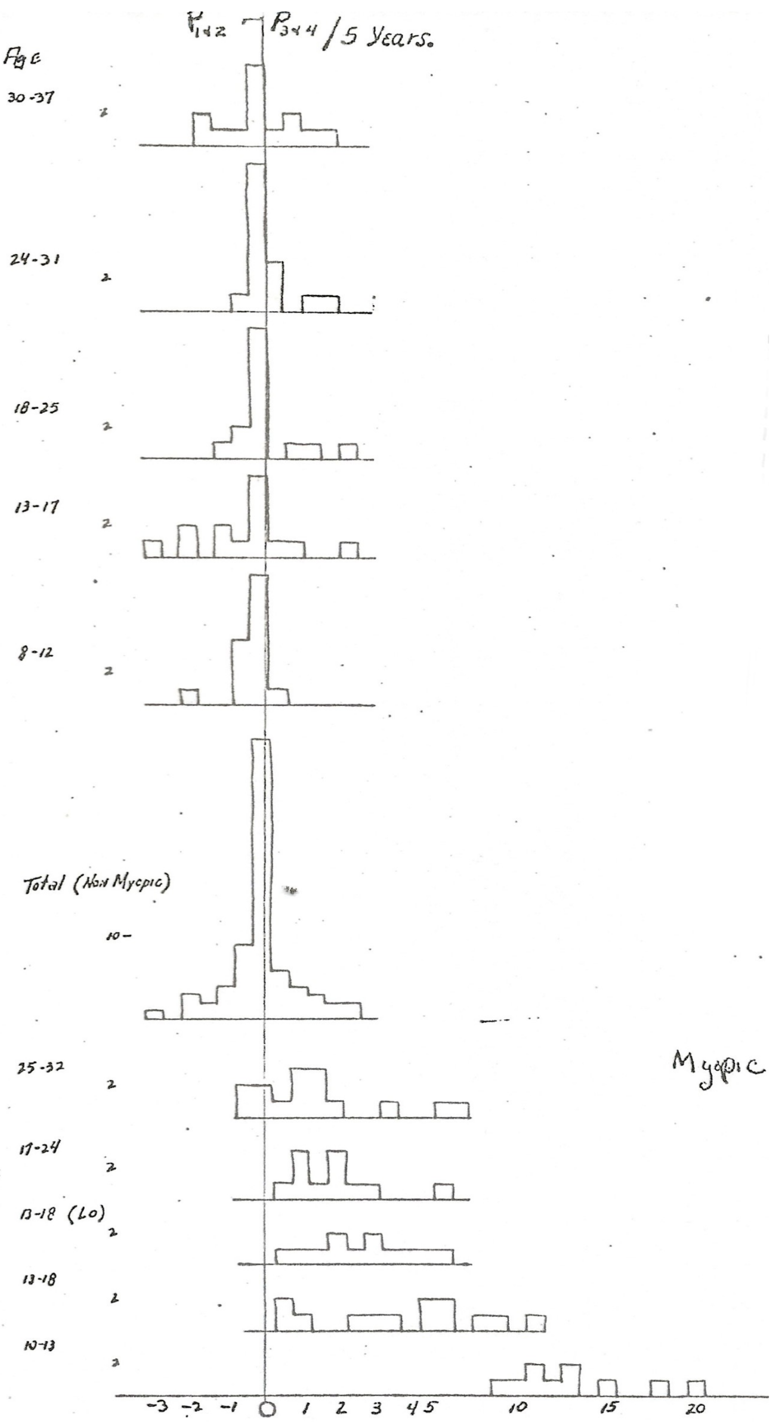

Figure 3. Frequency distributions of amount of change in P, in quarter-diopter units, for 70 non-myopic individuals and 70 myopic individuals. The five frequency distributions starting at the top of the figure are for non-myopic individuals in the age groupings of 30-37, 24-31, 18-25, 13-17, and 8-12 years, respectively. The sixth distribution from the top is for all non-myopic individuals. The five frequency distributions at the bottom of the figure are for myopic individuals in the age groupings indicated on the left side of the figure. The vertical line through all distributions indicates common orientation with the x-axis at the bottom of the figure.

the average is represented by the dotted curve. The sigma calculated for this distribution is 0.50 quarter diopter units, or 0.12 D. This comes close to the calculated sigma characteristic of P, even though the calculation is based on a very simple variation of the refractive value P with time. There is justification for considering the calculated lens P determinable with a sigma of +0.12 D. Such a value might be obtained also by measuring any one end point phenomenon four times per refractive examination, but the possibilities of idiosyncrasies in the response to any single distal stimulus might make this less desirable for inter-individual comparison. The sigma value 0.12 D allows definite significance to be ascribed to a difference of a quarter diopter in the value of P; this is also the unit of measurement used in standard refractive procedures.

Studies are being made using this value, P, as a base unit for comparison of more complex refractive characteristics of individuals in which the stimuli to accommodation are altered.

It is being used to study myopic progression and recession. For example, the amount of change of the value P over a five year interval for the 70 myopic individuals used in this paper compared with the 70 non-myopic individuals is shown in the distributions in Figure 3.