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A study of vertical imbalance at the reading level

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Abstract

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A STUDY OF VERTICAL IMBALANCE AT THE READING LEVEL

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INTRODUCTION

This study was made to determine any significant change in vertical phorias and ductions from the standard horizontal testing position to that of the reading level. The primary objective for investigating this testing procedure was to formulate a test directly correlated with most near point activities. After reviewing the papers in the literature concerning vertical phorias, it was found that many researchers implied that the only valid method of taking a near phoria test was in normal reading posture.

In his book, The Management of Binocular Imbalance, Krimsky discussed the shortcomings of the stand type double rotary prism phorometer and stated: "It is physiologically incorrect for near testing the vertical phoria. As constructed at the present time, the phorometer limits adjustment of the head to an erect position with the eyes directed straight ahead as for testing at far. Near testing would require the eyes to be directed somewhat downward. The phorometer does not permit such an adjustment."[1] For this study, however, it was possible to obtain a Steven's phorometer which could be rotated to allow the patient to look through the center of the prisms when the target was at his reading level. This instrument minimized any induced prismatic effect.

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[1] Arnold Krimsky, The Management of Binocular Imbalance, Prentice-Hall, 1959, p. 125.

The reading level used in this investigation was determined by experimentation and was validated by Meredith Morgan in a paper entitled "Accommodative Changes in Presbyopia and Their Correction." In his paper Morgan stated that "Ellerbrock found most individuals place their near work between 40 and 60° below the horizontal. About half of this distance is compensated for by tilting the head forward; thus the visual lines of sight are usually directed downward in reading about 20 to 30°."[2]

Hyperphoria that is greater at infinity than at the reading distance is usually due to involvement of a vertical rectus, and if the reverse is found, an oblique muscle is usually at fault. In frontal gaze in the distance, the vertical rectus muscles are the main elevators and depressors. At the reading distance the oblique muscles have the greater power with their power increasing greatly in convergence. The presence of a marked secondary deviation may obscure the picture.[3]

The vertical range of fusion is relatively small and so a slight error does not remain latent but becomes a hypertropia. Vertical fusion, unlike the normally strong fusion-control in convergence, is neither well controlled nor in constant use. It is known from experiments with prisms

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[2]Meredith Morgan, "Accommodative Changes in Presbyopia and Their Correction," Vision of the Aging Patient, p. 110.

[3]J. R. Anderson, M. D., Ocular Vertical Deviations and the Treatment of Nystagmus, p. 13.

that limited unilateral vertical movements do occur to maintain fusion. Verhoeff wrote that the duction mechanism is "the only known function that could prevent vertical deviation." By a conditioning process he thought that voluntary control over sursumduction could possibly be acquired.[4]

Normally we observe a unilateral vertical deviation when the strength of a rotating prism, held base up or down before one eye, is increased. Single vision is maintained by continued stimulation of corresponding retinal points as the eye behind the prism rotates up or down. Such movements are not due to unilateral muscular innervation. Opposite innervation goes to each eye and is neutralized in one by determination to fix and is effective in rotating the other eye with double force.

In this concomitant group there are the (1) Manifest squints: hypertropia; and (2) the latent type: hyperphoria. In both there is practically the same degree of deviation in all directions of gaze. As no muscle is chiefly affected, the double images show no obliquity. Neither does head-tilting affect the deviation. Fatigue and illness have been claimed to permit the latent to become the obvious defect.[5]

Past investigations have shown that there is a drop in exophoria at the reading level. A reduction of exophoria

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[4] Ibid., p. 14.

[5] Ibid., p. 14.

was found in 1955 by Dramen, Berman, and Dickes in their fifth-year thesis at Pacific University. This factor may be significant in measuring the vertical phoria because it is known that the vertical phoria may be influenced by different amounts of lateral dissociation prism. Thus, if a person exhibits less exophoria at the reading level, then less Base In prism will have to be given in order to cause dissociation. It has been stated by Adolf Posner that "the amount of hyperphoria uncovered depends upon the extent of dissociation. Consequently, the Maddox-rod test usually gives somewhat higher values than the red glass test. The mere fact that estimations of the amount of hyperphoria varies with the methods employed indicated that no method can be regarded as a reliable guide in the treatment of the condition."[6]

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[6]Adolph Posner, M. D., American Journal of Opthalmology, 1951.

METHODS

The equipment used in this study was:

A. One half arc perimeter with a fixation distance of sixteen inches.

B. Stand-type rotating phorometer with prisms of 1^{Δ} gradations.

C. A. O. phoropter with prisms of 1^{Δ} gradations.

D. Two cards, each with a single horizontal row of 20/20 letters placed centrally on each card.

The subject's habitual nearpoint Rx was determined and the experimental data was taken through this Rx. The first step was taking a standard #18 finding in the A. O. phoropter. The left eye was fixating while the vertical prism was rotated before the right eye till alignment. Both supra and infra ductions (Break and Recovery) were then measured before the right eye.

The subject was then seated out of instrument before the phorometer for further testing in the straight ahead and at the reading level 30^{o}. The subject was instructed to place his chin in the modified chin rest and forehead against headrest and was told to report when the single row of letters appeared centered in the lens wells before each eye. The Pd was changed until the patient reported such alignment. The dissociating prism was next placed before the left eye and the measuring prism before the right eye. A series of three phorias and two ductions (two supra and two infra) were taken.

The average time that the subject was dissociated for the phoria was 10 seconds. The average time taken for supra and infra ductions was 30 seconds. The prisms were then removed and fusion was allowed for a period of 30 seconds before the subject was directed to the 30^{o} depressed target. The target was next lowered to a level 30^{o} below the horizontal and the phorometer was rotated forward and down to regain a centered position in relation to the new line of sight. The same standard phoria and duction procedure was repeated at this level. The prisms were then reversed with the dissociating prism now before the right eye and the measuring prism before the right eye and the measuring prism before the left eye. Again a series of three phorias and two ductions were run.

The results of the data were compared as follows: First, the three phorias for each fixating eye for each section were averaged and assigned plus and minus values. Plus values indicate a right hyperphoria and minus values indicate a left hyperphoria. The averages for each fixating eye within each section were then compared with the same plus and minus notation.

Second, the ductions for each test were balanced (averaged) for both break and recoveries. Plus notation for supraduction and minus for infraduction. The ductions with the left eye fixating and with the right eye fixating for each testing

distance were then compiled into a single hyper value, either plus or minus.

The values for each test sequence were then compared and listed in table #1.

Vertical Phorias -- Table #1

Testing Position	Median	Variance	Standard Deviation
1. Standard #18	ø	2.81	1.67
2. 180° Phorometer	+.12	1.74	1.32
3. 30° Level in Phorometer	+.50	2.23	1.49

Vertical Phorias -- Correlation Coefficient

1. Standard #18 and Straight ahead Phorometer	-- .93
2. Standard #18 and 30°Level Phorometer	-- .76
3. Straight Ahead Phorometer and 30°Level Phorometer	-- .87

Vertical Ductions -- Table #2

Testing Position		Median	Variance	Standard Deviation
1. Standard #18		ø	.703	.84
2. Straight Ahead Phorometer	OD	ø	.376	.61
	OS	ø	.623	.79
3. 30°Level in Phorometer	OD	+.12	.726	.85
	OS	+.50	.887	.93

The graphs from this table show the results of the comparison of the different testing situations.

The same average time was taken for the phorias and ductions at the 30° reading level. The total average time taken to complete each patient was five minutes. The room illumination was 25 foot-candles.

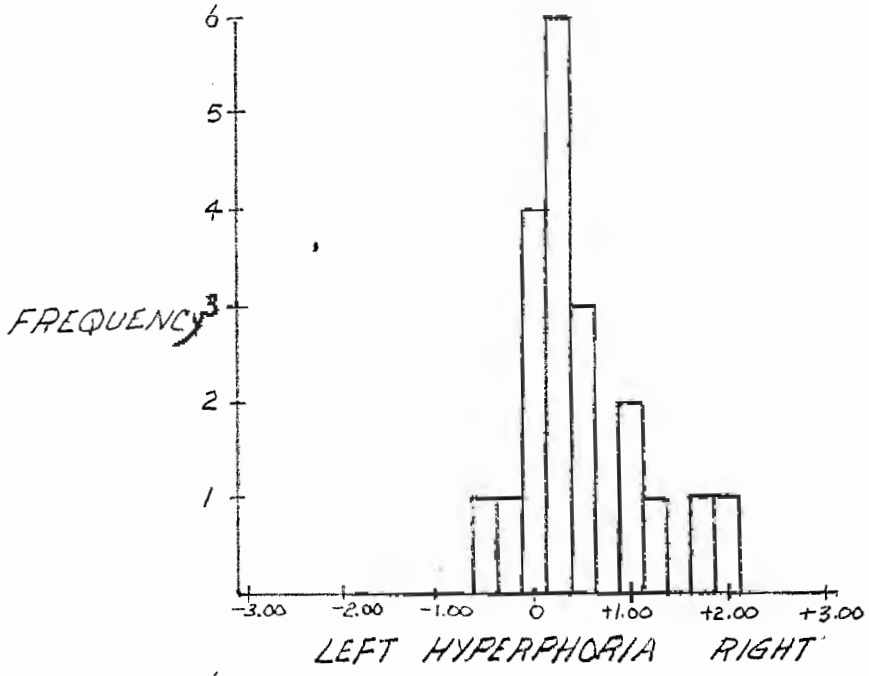
	PHORIAS			DUCTIONS				
	#18	Straight Ahead Phorometer	30°Level Phorometer	#18	Straight Ahead Phorometer		30°Level in Phorometer	
					OD fix	OS fix	OD fix	OS fix
1.	-3.10	-2.0	-.50	-.50	ø	-.25	-.50	-.25
2.	- .50	- .21	-1.00	- .12	ø	ø	-.75	-.50
3.	-3.60	-3.00	-2.50	-2.25	-.75	-1.00	-1.00	-.75
4.	-2.30	- .50	-1.50	- .75	-1.00	-1.12	- .50	-.50
5.	+ .50	+ .12	+1.00	+ .75	ø	ø	+1.25	+1.00
6.	- .50	- .33	-1.00	-1.00	-1.37	- .50	-1.37	-1.00
7.	ø	ø	+ .16	ø	- .50	ø	+ .37	+ .62
8.	+1.00	+ .83	ø	+ .50	+ .37	+ .12	+ .62	+ .50
9.	+1.00	+1.33	+1.00	+ .50	+ .12	+1.00	+ .25	+1.50
10.	+1.00	+2.16	+1.00	ø	ø	+ .12	+ .25	+ .25
11.	-1.50	-1.00	-1.75	-1.50	ø	- .50	- .12	-2.00
12.	+1.00	+1.00	+1.25	ø	+ .12	+ .37	+ .75	+1.50
13.	+1.00	+1.00	+1.50	+ .62	+ .50	+1.37	ø	+1.12
14.	ø	+ .25	+1.50	- .50	+ .50	+ .50	+ .12	+ .25
15.	-2.50	-1.50	-1.50	-1.62	- .37	- .25	-1.25	- .62
16.	ø	+ .25	+1.00	ø	ø	+ .37	+ .12	+ .50
17.	+ .50	+1.00	+2.75	ø	+ .31	+ .12	+ .31	+ .50
18.	-1.00	- .83	-1.75	ø	-1.00	- .25	-1.37	- .50
19.	+ .50	+2.50	+2.75	+ .75	+1.37	+1.75	+1.00	+1.62
20.	ø	ø	+ .50	- .25	- .12	- .75	+ .75	+ .62

Chart of the Averages of the Phorias and of the Duction tests.

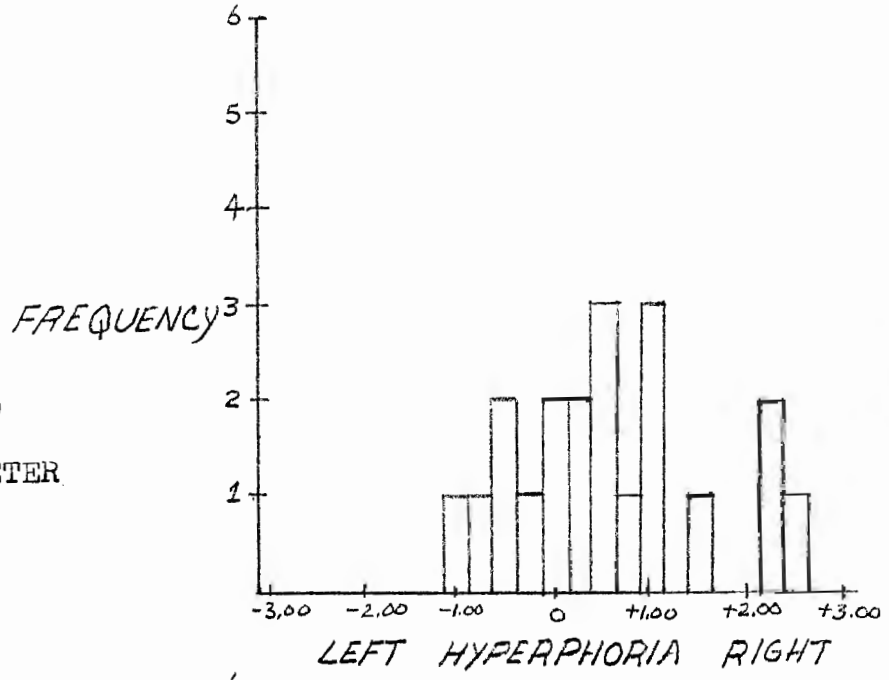
* Right hyperphoria indicated by plus sign.

Left hyperphoria indicated by minus sign.

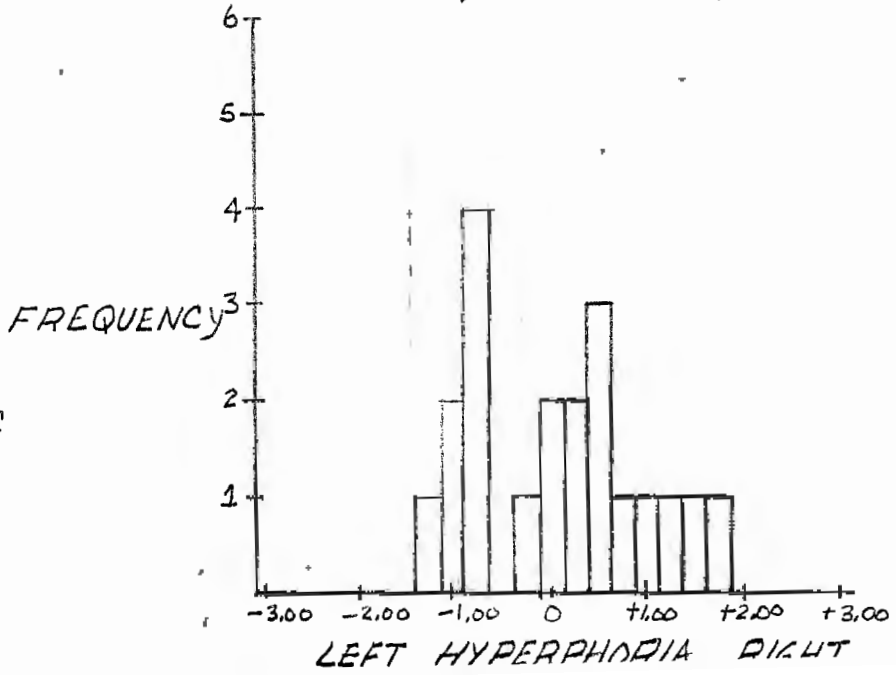
CHANGE OF PHORIA FROM THE STANDARD PHOROPTOR TO THE STRAIGHT AHEAD PHOROMETER



CHANGE OF PHORIA FROM THE STANDARD PHOROPTOR TO THE 30° LEVEL PHOROMETER



CHANGE OF PHORIA FROM THE STRAIGHT AHEAD PHOROMETER TO THE 30° LEVEL PHOROMETER



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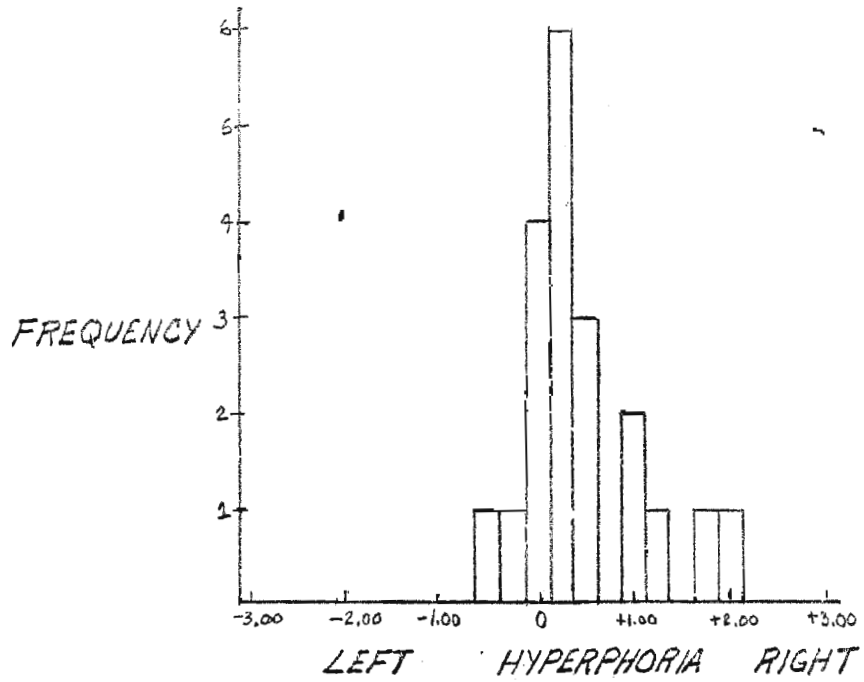
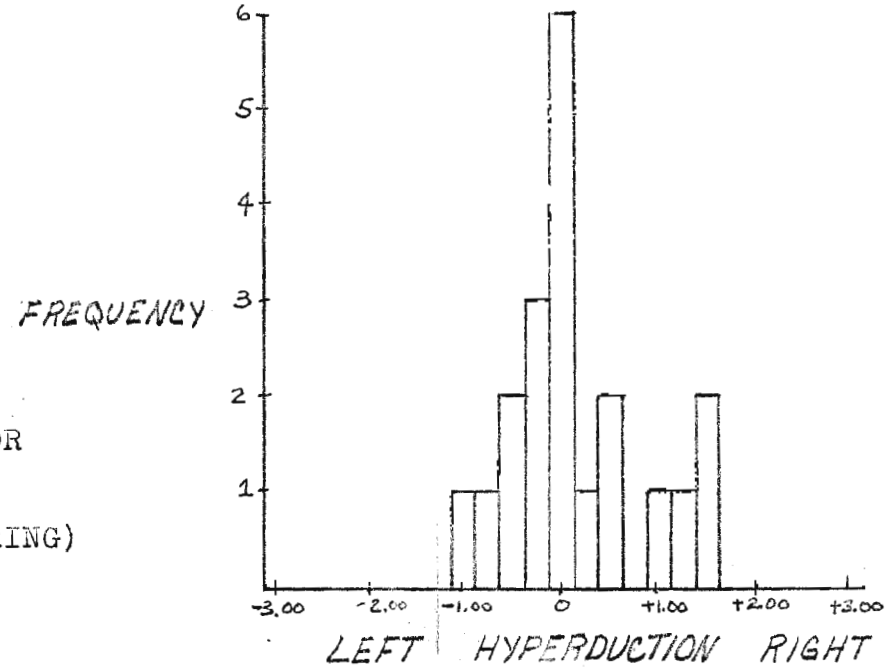


CHANGE OF THE DUCTION FROM THE STANDARD PHOROPTOR TO THE STRAIGHT AHEAD PHOROMETER (RIGHT EYE MEASURING)



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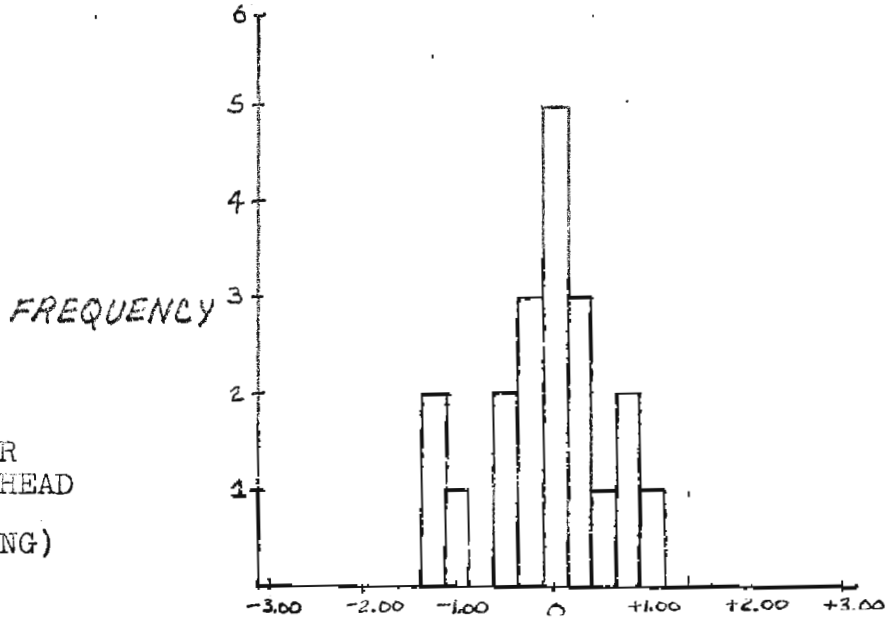
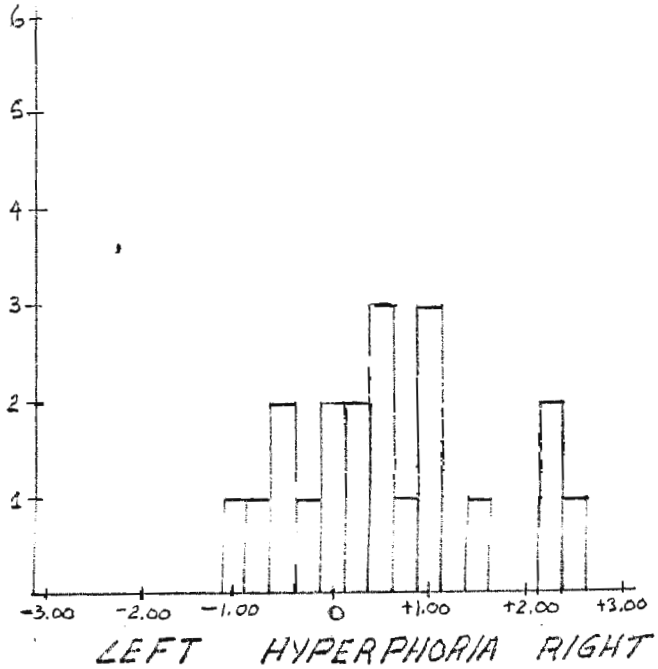


CHANGE OF THE PHORIA FROM THE STANDARD PHOROPTOR TO THE 30°LEVEL PHOROMETER



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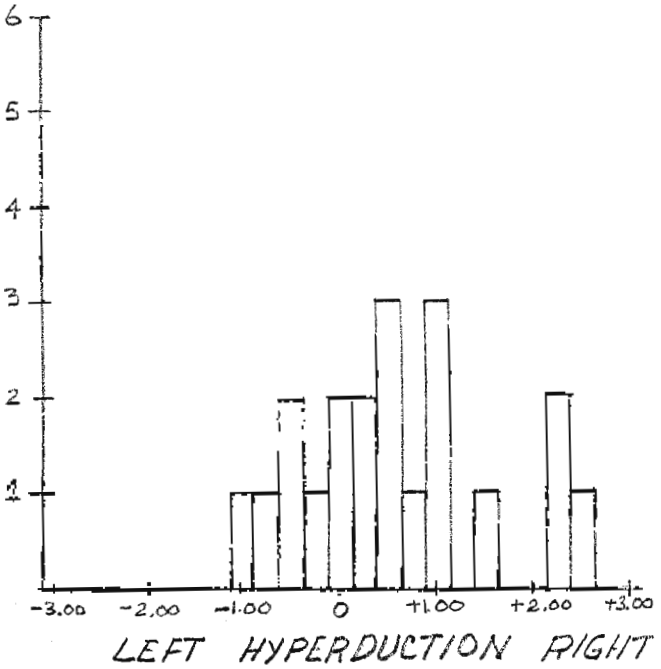

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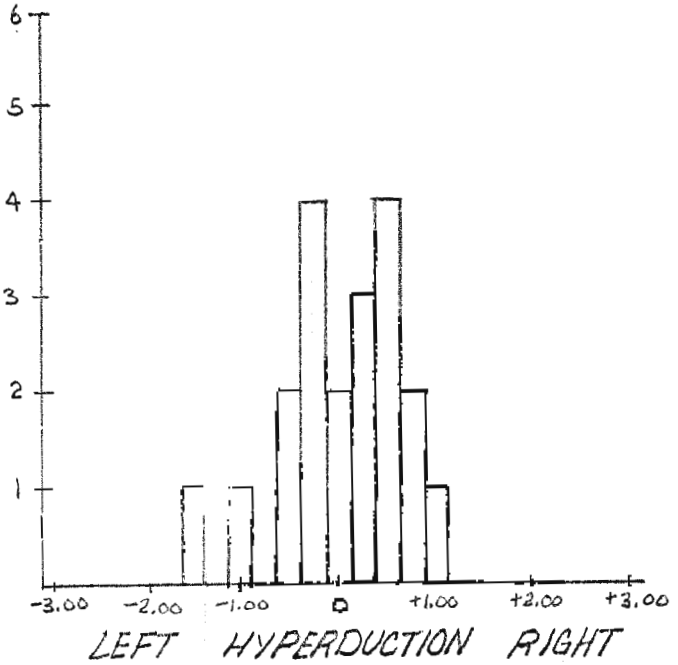
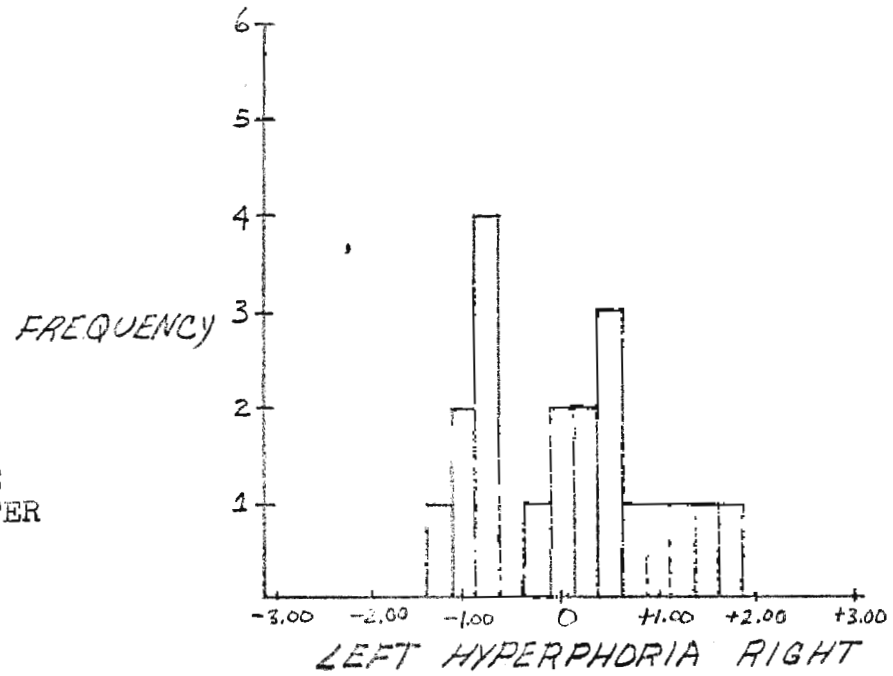
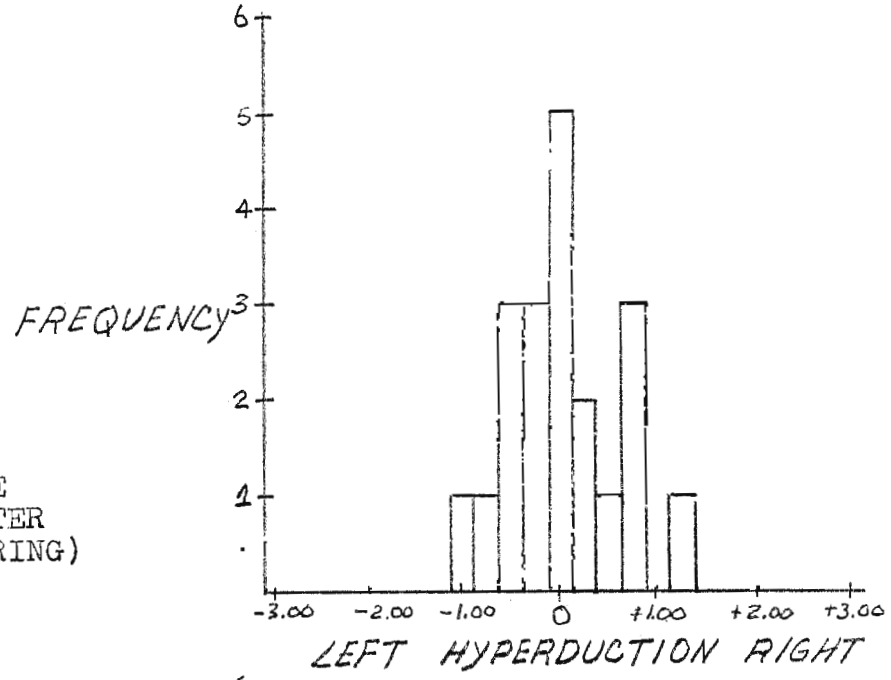


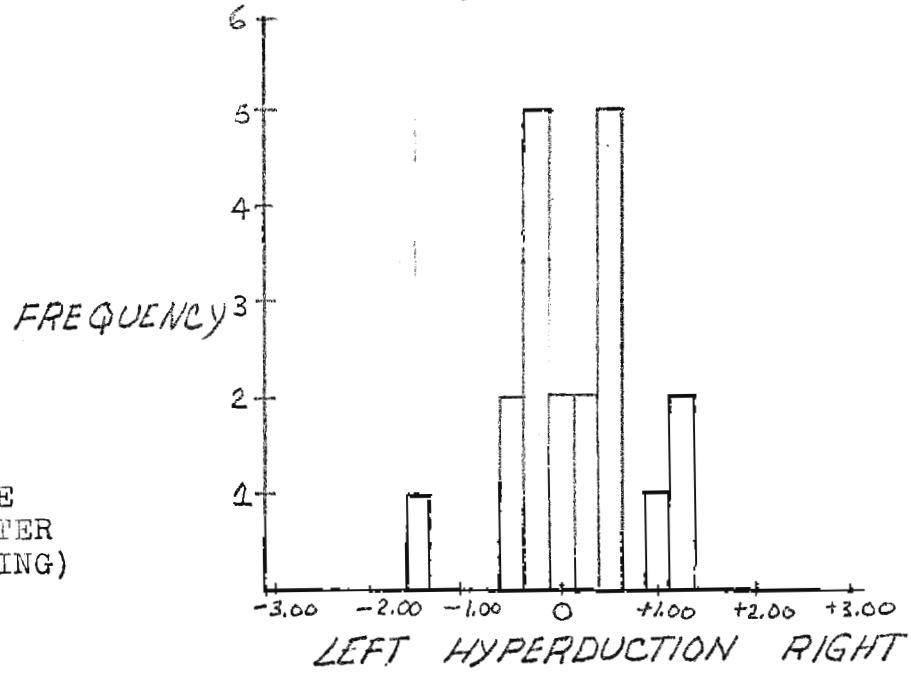
CHANGE OF THE PHORIA FROM THE STRAIGHT AHEAD PHOROMETER TO THE 30°LEVEL PHOROMETER



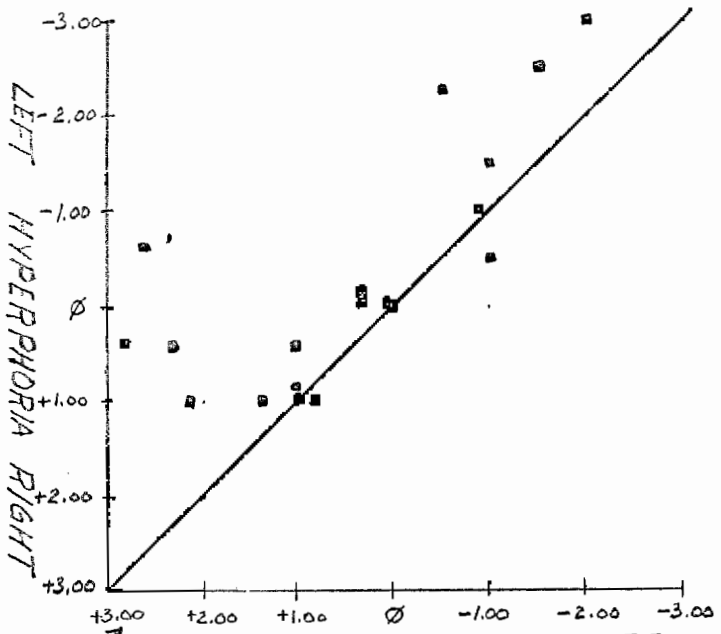
CHANGE OF THE DUCTION FROM THE STRAIGHT AHEAD PHOROMETER TO THE 30°LEVEL PHOROMETER (RIGHT EYE MEASURING)



CHANGE OF THE DUCTION FROM THE STRAIGHT AHEAD PHOROMETER TO THE 30°LEVEL PHOROMETER (LEFT EYE MEASURING)

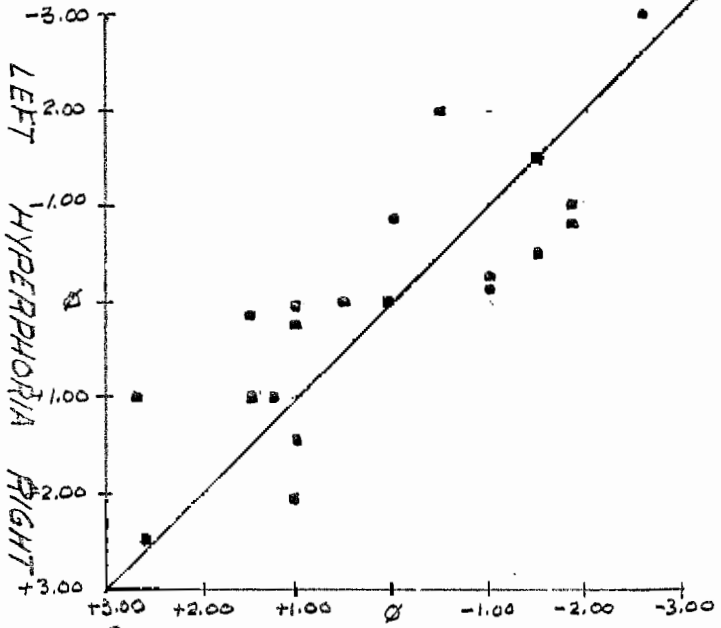


STANDARD #18



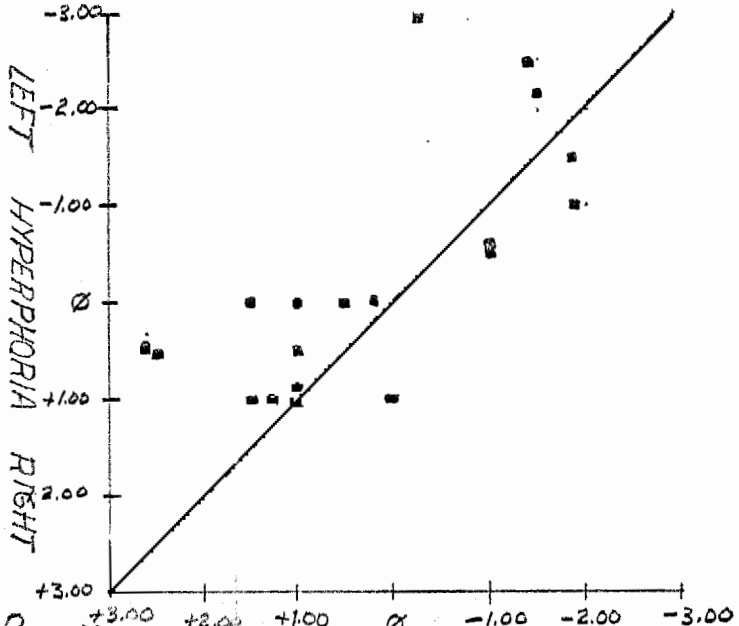
180° PHOROMETER → RIGHT HYPERPHORIA LEFT

180° PHOROMETER



30° PHOROMETER → RIGHT HYPERPHORIA LEFT

180° PHOROMETER



30° PHOROMETER → RIGHT HYPERPHORIA LEFT

RESULTS

The frequency graphs of the testing sequence show that the ductions vary little from the phorias regardless of the fixating eye. The best agreement between corresponding phorias and ductions is shown by the standard phoropter vertical sequence combined with the phorometer in the straight ahead position.

The least agreement was found in the comparison of the vertical phorias and ductions from the straight ahead phorometer to the 30^{o} level.

The ductions show that there is a better correlation with the phoria when the right eye is the measuring eye than if the left eye is used to measure the deviation.

It can be seen from table 1 that the difference between the median of the standard #18 phoria and the 180^{o} phoria in the phorometer was +.12. (The plus sign indicated a right hyperphoria.) This difference was constant with a correlation coefficient of .930. The difference between the median of the standard #18 phoria and the 30^{o} phoria in the phorometer was as great as +.50. The correlation coefficient between these two was not as consistent; it was .76.

The standard deviation of the #18 phoria in phoropter showed a greater variation from the standard mean of ortho than did the phoria at the 30^{o} reading level in the phorometer. The standard deviation of the 180^{o} phoria in the phorometer indicated the least variance of the three phoria positions.

The ductions show a consistent relationship with the median, variance, and standard deviation findings of the phorias in all three positions.

The formulas used to derive the statistics of this study were:

(1) $$S = \sqrt{\frac{\Sigma x^2}{n-1}}$$

Where S = standard deviation
x = deviation from mean
n = total number of subjects

(2) $$S^2 = \frac{\Sigma x^2}{n-1}$$

Where S^2 = variance
x = deviation from mean
n = total number of subjects

(3) $$P = \frac{1 - 6\Sigma D^2}{N(N^2-1)}$$

Where P = correlation coefficient
D = difference in ranks between two scores
N = total number of subjects

DISCUSSION

As indicated by the previous section, the similarities in data and statistical analysis are marked between the phoropter and the 30^{o} reading level phorometer findings. A significant difference is noted between the horizontal and 30^{o} phorias with a tendency toward right hyperphoria at the 30^{o} reading level.

As has been previously stated, Posner believes that the vertical phoria is influenced by the amount of lateral dissociation involved. In a previous thesis performed by Carkner and Roy, there was found to be a significant reduction of exophoria at the reading level. In this study minimal lateral dissociating prism was used in order to prevent fusion of the targets.

An attempt was made to minimize the effects of induced vertical phorias as a function of optical variables; however, no attempt was made to calculate the induced prismatic effect of the patient's Rx.

From the results of the experimental data, it can be deduced that if a vertical imbalance is suspected then vertical phorias and ductions should be conducted at the reading position in order to arrive at a more valid clinical analysis.

SUGGESTIONS FOR FURTHER STUDY

1. A study could be performed measuring vertical phorias and ductions first by limiting those who have no suspected vertical imbalance; secondly, limiting only the individuals who are known to have vertical imbalance and then comparing the relative changes of vertical phorias from the straight ahead position to that of the reading level.

2. Another interesting study could be one involving the measurement of vertical phorias in the "nine field" positions.

3. Still a third suggestion would be the measurement of change in vertical phorias from the horizontal position to the reading level but considering and calculating the errors in the data induced by lens powers and vertex distance.

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