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Abstract

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A Pilot Study Comparing Refractive Error and Preferential Looking Visual Acuity in Human Infants

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ABSTRACT:

A clinical pilot study comparing refractive error and Preferential Looking(PL) visual acuity in infants 2 to 12 months of age is described. The PL visual acuity of 30 infants was assessed using the "Acuity Card Procedure" PL technique developed by Teller and Dobson. Mohindra's dark room retinoscopy technique was used to determine refractive error. All infants of this sample had PL visual acuities within the norms established by McDonald and Dobson. Statistical analysis of the data for this sample of infants showed that refractive error does not change systematically from 2 to 12 months of age. We have found that the "Acuity Card Procedure" PL technique when utilized in a clinical setting agrees with infant visual acuity as described in the research literature. Refractive error did not correlate with changes in PL visual acuity in infants 2 to 12 months of age.

KEY WORDS: Acuity Card Procedure of Preferential Looking(PL), Dark Room Retinoscopy

Introduction

The need for early detection of visual anomalies has led to an explosion of research in the field of infant vision(1,2,3). This paper describes current clinical research being conducted at Pacific University College of Optometry Infant Vision Clinic. In cooperation with the University of Washington, Department of Psychology an apparatus was constructed for use with the "Acuity Card Procedure" Preferential Looking(PL) visual acuity assessment for infants. This form of preferential looking procedure was developed by McDonald and Dobson(4) after it became apparent that a more simplified and quicker method for acuity accessment was needed for clinical use. This procedure has allowed the establisment of estimated visual acuities for our infant subjects in a clinical setting. PL visual acuity norms for ages 1 to 12 months, both binocular and monocular, have been previously established in laboratory settings(5).

Mohindra has developed a non-cycloplegic refraction technique for infants(6). This technique is easily and quickly administered and provides a measurement of the infant's refractive error. Mohindra bases the procedure on research comparing subjective refraction and near retinoscopy values in adults(7). Norms for refractive error measurement for infants are not provided by Mohindra but correlations between cycloplegic refraction and the near retinoscopy technique in subjects is high(8). Reliability for the procedure is proposed to be excellent for independent observers(9).

Refractive errors of small groups of infants have been assessed by independent researchers(10). Norms for larger sample sizes of infants at specific ages is lacking in the literature. The purpose of this study was to 1) describe longitudinally the trends in refractive error and PL visual acuity for the first twelve months of life, 2) determine whether refractive error and visual acuity are correlated, and 3) confirm research norms for PL acuity testing in a clinical environment.

Methods

Subjects.

Thirty infants from two to twelve months of age were randomly selected from a local population. Subjects were obtained through visitors to the College of Optometry, by word of mouth, and from solicitation at the March 10, 1984 "Save Your Vision Week" screening conducted at Portland's Memorial Coliseum.

During the first session a brief case history was obtained. It included the infant's birth and due dates, birth weight, complications during or after pregnancy, the infants general health, observations of visual distress or strabismus, and a brief familial ocular and general health history. Scheduling for examinations was based on the post-gestational age of the infants(40 week term). The infants were scheduled for their examinations at two month intervals from their due dates. Testing for this pilot study extended over an eight month period.

Examination Procedures.

Entrance testing followed the case history. A Hirschberg test, near point of convergence, eye movements, pupil responses and ophthalmoscopy were performed on each infant. Visual acuity and refractive error determination then followed.

The "Acuity Card Procedure," was then utilized to estimate the visual acuity of the subjects. The apparatus (see fig. 1) was constructed from specifications obtained from the University of Washington, Department of Psychology(5). A modification allowing use of a television camera and monitor(CCTV) was installed such that the person holding the infant could also serve as the trained observer. This system is similar to the "Standard Forced Choice Preferential Looking" apparatus developed at the University of Washington, Department of Psychology(11).

A testing distance of 34 cm. was utilized for this study. The Snellen equivalents for the square wave gratings available to the observer were 20/3200, 20/1600, 20/800, 20/400, 20/200, 20/100, 20/50, and 20/25. Illumination of the apparatus was provided by overhead fluorescent lights and two high output floor lamps.

Monocular testing was done on all subjects. A Coverlet eye patch was utilized for occlusion of the non-tested eye. Infants two to six months of age were held in the "flying hold" position(5) before the apparatus(see fig. 2). The infant was then leaned forward, projecting the head toward the acuity cards thus keeping the eyes looking up and ahead.

The initial spatial frequency presented was one octave below the expected acuity potential for their age. The right or left position of the acuity grating was accomplished by the subjective choice of the trained observer.

The infant was then positioned in front of the screen. The subjects position was adjusted to allow the trained observer to monitor eye movements or fixation patterns on the television monitor. Testing proceeded until the observer judged the subject no longer fixated the striped pattern, indicating that the acuity threshold had been reached. The procedure was then repeated on the opposite eye. Along with acuity estimates, a note on the confidence of each observation was recorded.

For infants eight to twelve months of age we found it increasingly difficult to utilize the CCTV arrangement due to increased activity and decreased cooperation by the subjects. The testing procedure was then changed such that the observer positioned him/herself behind the apparatus and directly assessed fixation through the peephole. A second experimenter was then used to hold and position the subject. Noise makers, puppets, bells and other attention attracters were utilized to maintain interest. Occasionally, the parent was asked to hold the subject.

Dark Room near retinoscopy as developed by Mohindra was then utilized to ascertain refractive error(6). The parent was seated in a totally darkened room with the infant sitting in the lap, facing the examiner. Lens bars or accommodative flippers were placed close to the infant's face while neutralizing the meridia at a working distance of 50 cm. Often rattles, squeekers, or verbal coaxing was needed to keep the infant awake and attending to the light. On occasion a flashing Trans-lid Binocular Interaction Trainer(TBI) was used at the plane of the retinoscope to hold attention on the retinoscope light. An average of 30 minutes was required to accomplish the entire battery of tests.

Statistical Analysis

All PL visual acuity data was converted to logarithmic form for statistical analysis. A probability of .05 was chosen for this study to establish significance. Repeated analysis of the data required the basic level of significance to be increased by the number of times the data was manipulated.

T-tests for related samples were conducted to determine intra-subject changes in refractive error and PL visual acuity over time. Data was paired from the same eye. The adjusted levels of significance for refractive error was .005 (.05/11) and .006(.05/8) for visual acuity. T-tests for independent samples were conducted to determine if inter-subject refractive error changed systematically over time. The adjusted level of significance was .003(.05/15). T-tests for independent samples were conducted on PL visual acuity. The adjusted level of significance for this study was .007(.05/7). A Pearson r correlation for refractive error and visual acuity was performed at each age interval. The absolute value of the refractive error in spherical equivalents were paired with the PL visual acuity for each eye.

Results

Of the thirty infants, three were born three or more weeks before or after the scheduled due date and none exhibited strabismus, any unusual general health nor any other ocular problems. Each child was seen an average of three times during the study.

Of the 85 clinical trials for monocular PL VA, 77 of 85(91%) were successful in attaining visual acuities in both eyes,With five of the trials acuity was obtainable only on one eye, while, on the remaining three trials, monocular testing was not tolerated, but binocular acuities were obtained.

Descriptive statistics for refractive error and PL visual acuity for this sample population of infants is summarized for each age group(see table 1). For this sample, the mean spherical equivalent of the refractive error for two month intervals from 2 to 12 months ranges from .25 to 1.00 diopter of hyperopia. The standard deviations were relatively large and indicate considerable variation within the age groups. Figure 3 depicts the change in mean refractive error from 2 to 12 months of age for our population of infants. The mean refractive error in spherical equivalents remains in low hyperopia and stays there throughout this period. The PL visual acuity improves rapidly from 2 to 6 months and levels off at near 20/100 at 10 to 12 months of age. Standard deviations of this sample population were relatively small. The mean PL visual acuity of our subjects in this study fell inside the range of norms established by McDonald, Dobson, Sebris et.al.(5). Figure 4 illustrates that the standard deviation of our sample is smaller than the clinical norms found by McDonald, Dobson, Sebris et.al.

When T-tests for related samples were conducted to determine intra-subject changes in refractive error and PL visual acuity over time, it was found that refractive error was not significantly different for any of the age intervals(see table 2), while the mean PL visual acuity for one of the two month intervals and all of the four month intervals, except for the eight to twelve month inverval, was statistically significant(see table 2).

When T-tests for independent samples was conducted to determine inter-subject changes in refractive error over time it was found that none of the age groups were found to be significantly different from any other age groups(see table 3). Results of T-tests for independent samples on PL visual acuity data was found to be significant in three of five age comparisons at two month intervals. Of the two not significant at the two month interval one was significant at a four month interval(see table 4). When a Pearson r correlation for refractive error and PL visual acuity was performed at each age interval no significant correlation was found(see table 5).

Discussion

Our results indicate that the "Acuity Card Procedure" of PL visual acuity testing is a useful clinical tool in assessing acuity in infants ages 2 to 12 months. Our PL visual acuity results, showing significant differences in the mean acuity at two to four month intervals, supports the use of the "Acuity Card Procedure" PL technique as a means of identifying an infant's acuity as normal or abnormal for his/her age. The high percent testable also supports the clinical use of the Acuity Card Procedure for acuity testing with infants two to twelve months of age.

The relatively small standard deviation of our PL visual acuity data as compared to McDonald, Dobson, and Sebris(5) can possibly be explained by the homogeneous nature of the sample or by experimenter bias inherent in this subjective testing procedure.

The fact that our group of infant's refractive error did not change significantly during the testing period could be explained by 1) Mohindra's near retinoscopy technique is not sensitive enough to detect refractive error changes in this infant population; 2) this sample of infants is not representative of the true refractive state of the greater population; 3) the mean refractive state of early infancy is low hyperopia and remains so up to 12 months without substantial change.

The refractive status of infants may have an important relationship to visual acuity as tested using the "Acuity Card Procedure." The testing prodecure using a 34 cm testing distance would require 3 diopters of accommodation for conjugate focus at the plane of the acuity card for an emmetropic subject. We might expect that large refractive errors would decrease visual acuity in infants as in adult subjects. One must question, does refractive error effect visual acuity in infants?

Accommodative accuracy has been shown to improve from birth to near adult performance between the ages of 1 to 4 months of age (11,12,14).

Powers and Dobson(15) studied the effect of lens induced artificial blur on infants' visual acuity. They showed that visual acuity in infants aged 6 weeks is degraded less than one octave with as much as +6 to -3 diopter lenses.

The refractive error spherical equivalent of all of our subjects was with in +,-3 diopters on 96.1% of the measurements. If one assumed the infants did not accommodate at all during testing then the range of blur due to refractive error and test distance would have been from +6 to 0 diopters. This blur from refractive error is within the range of lens powers used by Powers & Dobson(15). We would expect that less than a 1 octave degradation of acuity could be attributed to the refractive error of our subjects. Since infants do accommodate to near stimuli this illustration would be a "worst case" treatment of the effect of refractive error on PL visual acuity for our subjects..

Boltz, Manny and Katz(16) have found that infants are effected significantly by less induced lens blur than that found by Powers and Dobson(15). Using a Forced Preferential Looking staircase procedure to obtain PL acuities and Mohindra's technique to obtain refractive errors they found that a group of seven infants' visual acuities were degraded significantly (1/2 octave) with as little as one or two diopters of induced blur. Blur effects were variable. Some infants were not significantly effected with as much as +6 diopters blur and others were significantly effected by as little as .25 diopter of blur. Inappropriate accommodation was not considered to be the cause for the decrease in acuity. The variability of the data among subjects suggests that further research is indicated in this area.

If a large amount of induced blur did not produce reduced visual acuity, as measured by PL, then the use of the PL technique to screen for anomalies in refractive error is questionable. Whether naturally occuring refractive error, anisometropia, or insufficiencies in accommodative abilities would produce marked decrements in PL visual acuity should be a topic of future study. Our results of no significant correlation between refractive error and PL visual acuity only indicates that low to moderate refractive errors (+,-3.00D from emmetropia) did not produce noticeable decrements in PL visual acuity. We would not have expected such decrements. At the 34 cm testing distance any 3.00D myope or hyperope (with sufficient amplitude of accommodation) would achieve conjugacy without rega
rd to the effects of depth of focus.

It is important for the clinician to be able to identify the at-risk infant and those who would benefit from optometric therapy. The highly variable refractive status of infants ages 2 to 12 months remains as a barrier to predicting changes in spherical or astigmatic errors(17). This dilemma indicates the need for norms in measurement of infant refractive error in a larger more variable population. Future studies will continue the assessment of refractive error and PL visual acuity initiated by this pilot study. Normative studies on Mohindra's retinoscopy procedure, and comparision to other refractive techniques appropriate to infant testing are planned. From these studies we hope to provide needed information on refractive norms and sensitivity of these techniques when used with infants.

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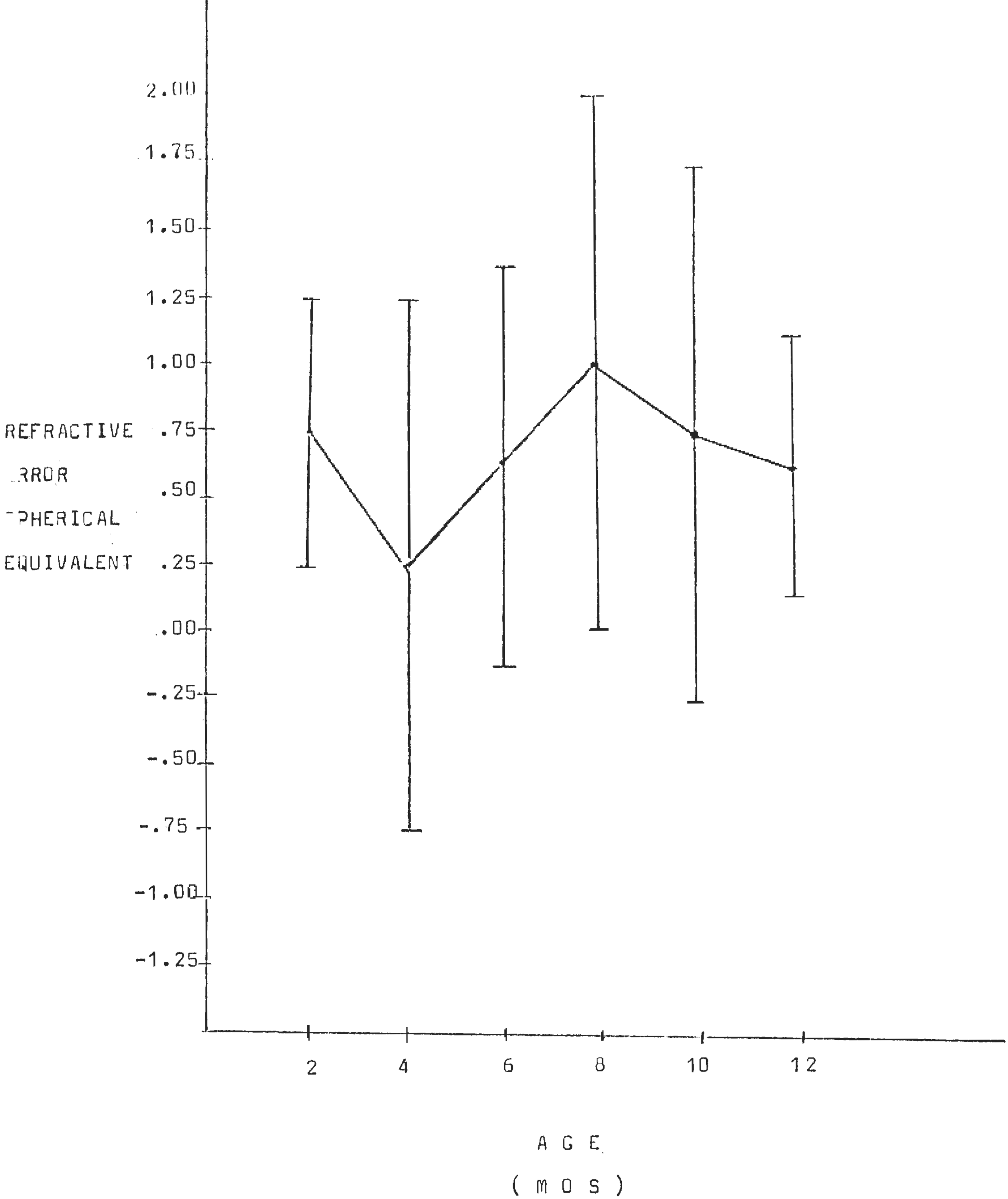
F I G. 1

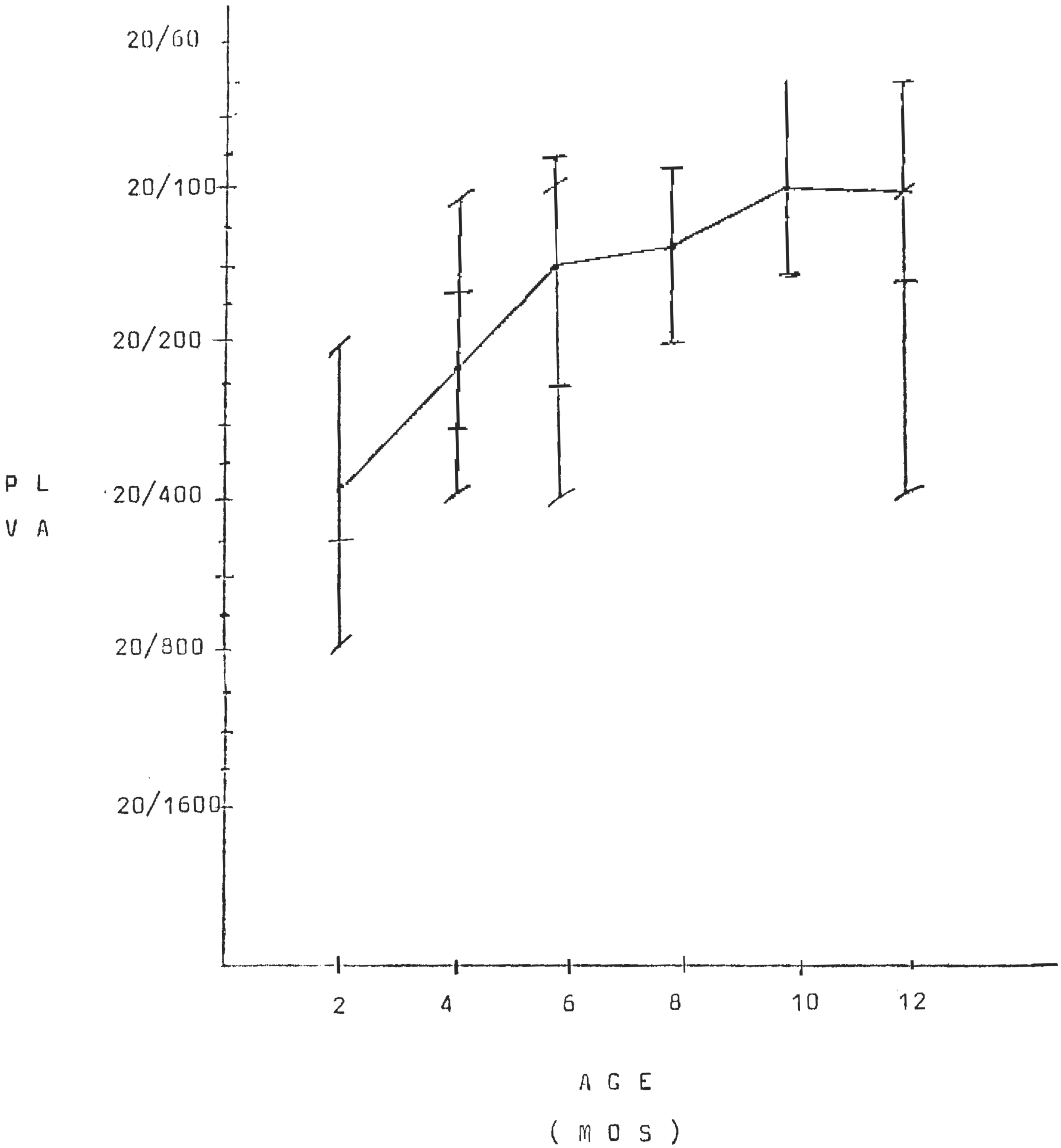
FIG. 2 ("FLYING HOLD POSITION")

FIG. 5



INDICATES $\overline{X} \pm 1$ S.D.

F I G. 4



indicates x̄ ± 1 s.d.

indicates PL norms taken from

McDonald, Dobsen, Sebris et. al. in preparation

T A B L E 1

DESCRIPTIVE STATISTICS

Age in Mos.	RE SPH EQUIV(1) Mean Range	s.d.	N*	PL VA(2) Mean Range	s.d.(3)	N(4)
2	+.75	.50	14	20/381	.442	16
	+.25 to +1.75			20/200 to 20/800		
4	+.25	1.00	30	20/235	.435	29
	-2.25 to +1.75			20/200 to 20/400		
6	+.625	.75	42	20/145	.671	41
	-.625 to +3.25			20/50 to 20/400		
8	+1.00	1.125	30	20/137	.561	33
	-.625 to +4.25			20/100 to 20/400		
10	+.75	1.00	28	20/97.5	.575	28
	-.50 to +3.5			20/50 to 20/200		
12	+.625	.50	10	20/100	.601	12
	0.00 to +1.50			20/50 to 20/200		

(1) RE mean and s.d. rounded to .125 D.
(2) PL VA rounded to three significant figures.
(3) PL VA s.d. shown in octaves(oct=log s.d./.301)
(4) N is number of eyes.

T A B L E 2

T-TESTS FOR SIGNIFICANT CHANGES
(Intra-Subject Changes)
Refractive Error in Spherical Equivalent

Ages Compared	N	Probability(1 tailed test)
2 to 4 mos.	11	.025
2 to 6 mos.	10	.12
2 to 8 mos.	8	.123
4 to 6 mos.	24	.249
4 to 8 mos.	18	.031
4 to 10 mos.	12	.116
6 to 8 mos.	18	.093
6 to 10 mos.	18	.279
6 to 12 mos.	4	.000
8 to 10 mos.	19	.039
8 to 12 mos.	9	.343

PL VISUAL ACUITY

2 to 4 mos.	12	.026
2 to 6 mos.*	15	<.001
4 to 6 mos.*	23	<.001
4 to 8 mos.*	16	.006
6 to 8 mos.	26	.351
6 to 10 mos*	18	.005
8 to 10 mos.	19	.039
8 to 12 mos.	8	.343

*Indicates significance at .05 level adjusted for the number of times t-test was used.

TABLE 3

T-TEST FOR INDEPENDENT SAMPLES

REFRACTIVE ERROR

(Inter-Subject Changes)

Interval	Ages Compared	ANOVA Results
2 month	2 to 4 mos	T(42) = 1.904, p = .061
"	4 to 6 mos	T(70) =-1.795, p = .074
"	6 to 8 mos	T(70) =-1.718, p = .087
"	8 to 10 mos	T(56) = .905, p = .373
"	10 to 12 mos	T(36) = .301, p = .688
4 month	2 to 6 mos	T(54) = .811, p = .426
"	4 to 8 mos	T(58) =-2.705, p = .008
"	6 to 10 mos	T(68) = -.581, p = .567
"	8 to 12 mos	T(38) = .961, p = .335
6 month	2 to 8 mos	T(42) = -.653, p = .524
"	4 to 10 mos	T(56) =-1.846, p = .067
"	6 to 12 mos	T(50) = -.080, p = .537
8 month	2 to 10 mos	T(40) = .172, p = .649
"	4 to 12 mos	T(38) =-1.163, p = .251
10 month	2 to 12 mos	T(22) = .725, p = .482

T A B L E 4

T-TEST FOR INDEPENDENT SAMPLES

PL VISUAL ACUITY

(Inter-Subject Changes)

Interval	Ages Compared	ANOVA Results
2 month	2 to 4 mos*	T(43) = 5.104, p =<.001
"	4 to 6 mos*	T(68) = 4.941, p =<.001
"	6 to 8 mos	T(72) = .559, p = .581
"	8 to 10 mos*	T(59) = 3.350, p = .001
"	10 to 12 mos	T(38) = -.177, p = .652
4 month	6 to 10 mos*	T(67) = 3.666, p =<.001
"	8 to 12 mos	T(43) = 2.348, p = .022

*Indicates significance at .05 level, adjusted for the number of times t-test was used.

TABLE 5

PEARSON R CORRELATION

REFRACTIVE ERROR AND PL VISUAL ACUITY

Age	N	Correlation Coefficient (r)
2 mos	14	0.000
4 mos	27	-.373
6 mos	41	.263
8 mos	29	-.247
10 mos	28	.132
12 mos	10	-.025