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Degree Type
Thesis

TESTING TECHNIQUES TO EVALUATE INFANT VISION

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ABSTRACT

Recent research on sensitive periods supports the need for early diagnosis and treatment of visual conditions such as strabismus, amblyopia, and high refractive error. Therefore, the optometrist should be equipped with an appropriate test battery to examine infants ages 0-3 years. The authors used a survey to determine the current status of infant testing by optometrists in the United States. A discrepancy was found between recent developments in techniques to measure refractive status and visual acuity, and techniques currently in use. A test battery is presented which should enable the optometrist to expand her/his practice to include infants ages 0-3 years.

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Introduction

Recent research indicates that critical periods exist for the development of normal visual function and performance.[1,2] It is imperative that conditions such as strabismus, amblyopia, and high refractive errors be detected in the first few years of life so that proper therapy can be instituted in order to insure normal visual development. Also, the public has become more aware of these visual conditions and preventative early visual care. This research and public awareness have lead optometry to question the present methods utilized to appraise the visual status of an infant. Many of these methods are procedures used on adults that are modified in some way for the infant, and do not adequately assess the visual system of the younger age group. This indicates a need for the optometrist to be well equipped with a battery of tests that take into account infant behavior and ability to respond which enable her/him to sufficiently evaluate the child age 0-3 years.

It is the intent of the authors to demonstrate that this need exists, discuss the testing techniques presently in use, and make available a battery of current and appropriate tests to evaluate infants. We have drawn on current knowledge from the literature, and from information obtained through a survey of optometric educators and practicing optometrists. This

information has been consolidated into a useful format and is designed for the optometrist who is interested in expanding her/his practice to include this select patient population.

Rationale

Investigation into infant vision has opened a rapidly expanding area in optometry with the establishment of infant vision clinics at optometry schools and other universities, increased interest by optometrists indicated by a limited number of them specializing in infant vision care, and various articles in the literature pertaining to the subject of infant vision testing. These publications elaborate on new testing techniques which have recently been developed that take into account the infant's behavior and ability to respond. However, these new methods as well as conventional techniques are presented sporadically in the literature. Several authors do describe a specific testing sequence for infants,[3-17] but most fail to reflect the advances that have been made in the area of infant testing.[3,4,6-13,15-17] Therefore, the optometrist who looks to the literature for an updated sequence will have difficulty acquiring the knowledge she/he needs to provide complete patient care.

Methods

A review was made of the literature with respect to individual testing techniques and available testing sequences for infants age 0-3 years. The literature was compiled from

a computer search of articles relevant to infant vision and techniques to assess it.

A questionnaire was assembled and distributed to survey the techniques currently being utilized by a sample of optometrists who are most likely to evaluate infants. Questionnaires were also sent to optometric educators who specialize in infant and developmental vision at all optometry schools in the United States. The survey covered several areas which included asking the participants to give the percentage of infants 0-3 years of age seen in their office per month. The survey also questioned at what age it was felt appropriate for a child's first visual examination. Participants were asked to identify which areas of performance should be tested from the following list: refractive status, visual acuity, ocular motilities, accommodative system, binocularity, external/internal health, development, and perceptual-motor. An "other" category was provided for write-in responses. Under each of these areas specific tests were listed. Each optometrist was asked to rank sequentially the tests used within each performance area with #1 denoting the most used test. Each performance area included an "other" response for tests not specifically mentioned on the survey allowing for a write-in response. The last section of the survey asked participants if a particular infant exam sequence was customarily used. With a yes answer, they were given the opportunity to present the actual sequence recommended.

Articles from the literature review that outlined an infant testing sequence were extracted. From these articles specific tests in a given sequence were tabulated so that their frequency could be easily compared with the survey data.

Results

Seventy-five percent of the sample of practicing optometrists indicated that their practice was mainly geared toward vision training and developmental vision, with 14% specifying children's vision as a specialty area. The majority of the population was represented by optometrists aged 30-40 years (33%) and 50-60 years (30%), and from 31 states, with the greatest proportion practicing in California (18%).

Few optometrists are seeing patients in the 0-3 years age group according to the survey. The majority of optometrists (90%) reported that this age group comprises 5% or less of the total patients seen. Approximately equal numbers of optometrists responded that either 5%, 2%, 1% or less of their patients are infants (22%, 16%, 16%, and 20% respectively). Instructors at optometry schools were asked to report in terms of actual numbers of infants seen each month in the infant or pediatric clinic. The average number of infants seen in clinics at colleges of optometry is 31 per month. It is apparent that infants age 0-3 years represent a very small segment of the optometric patient population.

The age at which to first examine a child has often been a matter of controversy. Of surveyed optometrists, 39.2% indicate that the first exam should occur between ages 0-1 year. Twenty-nine percent recommend at ages 1-2 years and 23.5% recommend ages 3-4 years. A significant difference was found in instructors' responses, with 68.4% indicating ages 0-1 year, only 10.5% indicating 1-2 years, and 15.3% responding 2-3 years.

Practicing optometrists and instructors were more in agreement regarding performance areas that should be evaluated during the infant exam. One hundred percent of both groups indicated that ocular motilities and external/internal exam must be performed. Instructors were also unanimous regarding refractive status and visual acuities (practicing optometrists designated these areas 98% and 84.3% respectively). On the whole, the majority of the two groups indicated that each of the performance areas listed is important with accommodation, development and perceptual-motor selected less frequently (optometrists 84.3%/instructors 78.9%; 84.3%/89.5%; 86%/89.5% respectively).

The frequency of tests used within the different performance areas for ranked responses 1-3 (1 meaning most used test) is illustrated in Table 1. The responses from sixty-six practicing optometrists (A) can be compared to those from fourteen instructors (B). This data was compiled from surveys using the appropriate ranking method requested.

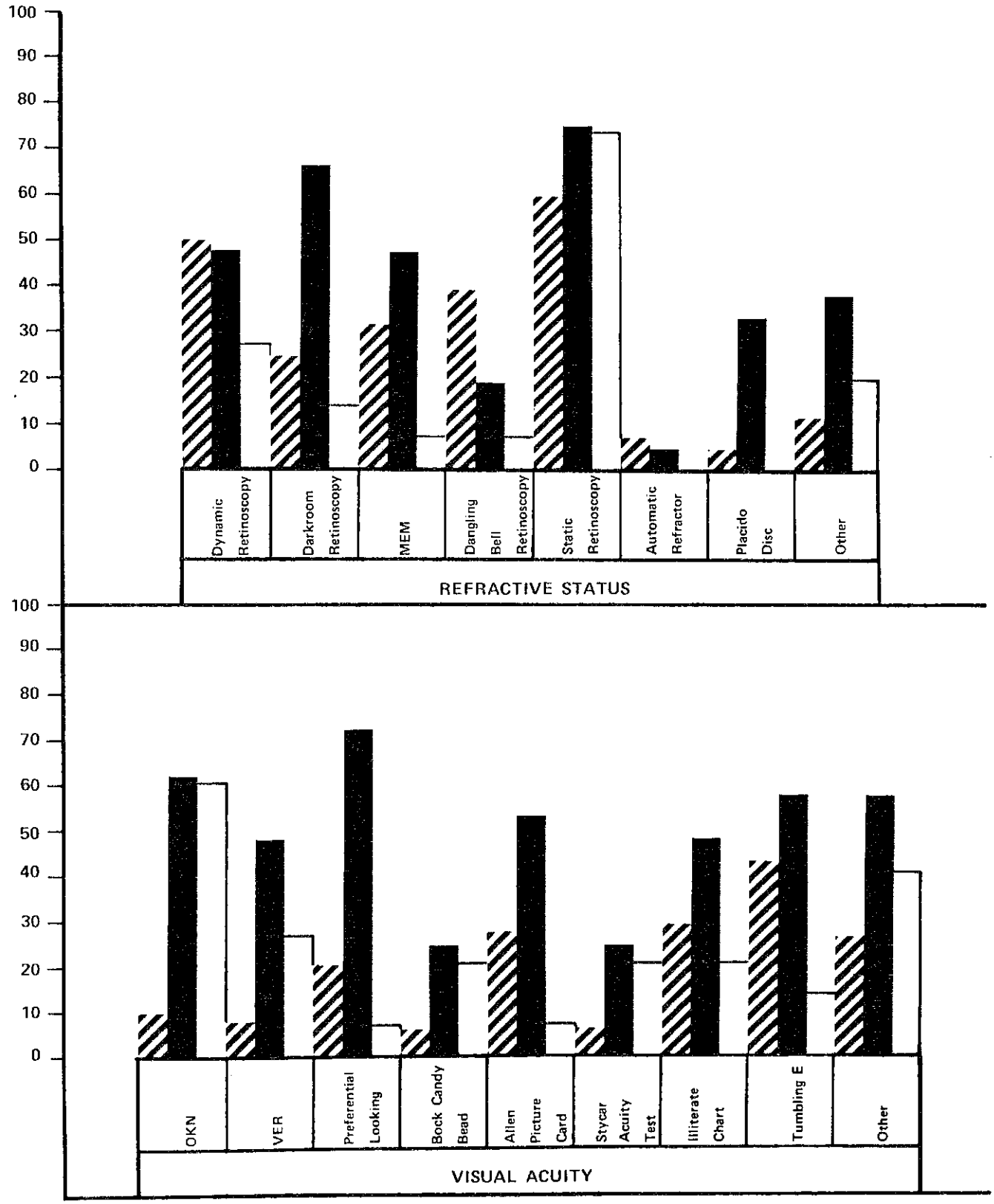
Figure 1 represents data compiled from all surveys received from practicing optometrists and instructors, and also an accumulation of tests indicated in sequences found in the literature. The collection of data from all surveys received (N = 105) includes surveys in which answers were not ranked but merely checked off. It was assumed that such a response meant that the test was used at some time or another. Therefore, Figure 1 represents frequency of tests used only at some point in time, and not necessarily the most used or preferred tests.

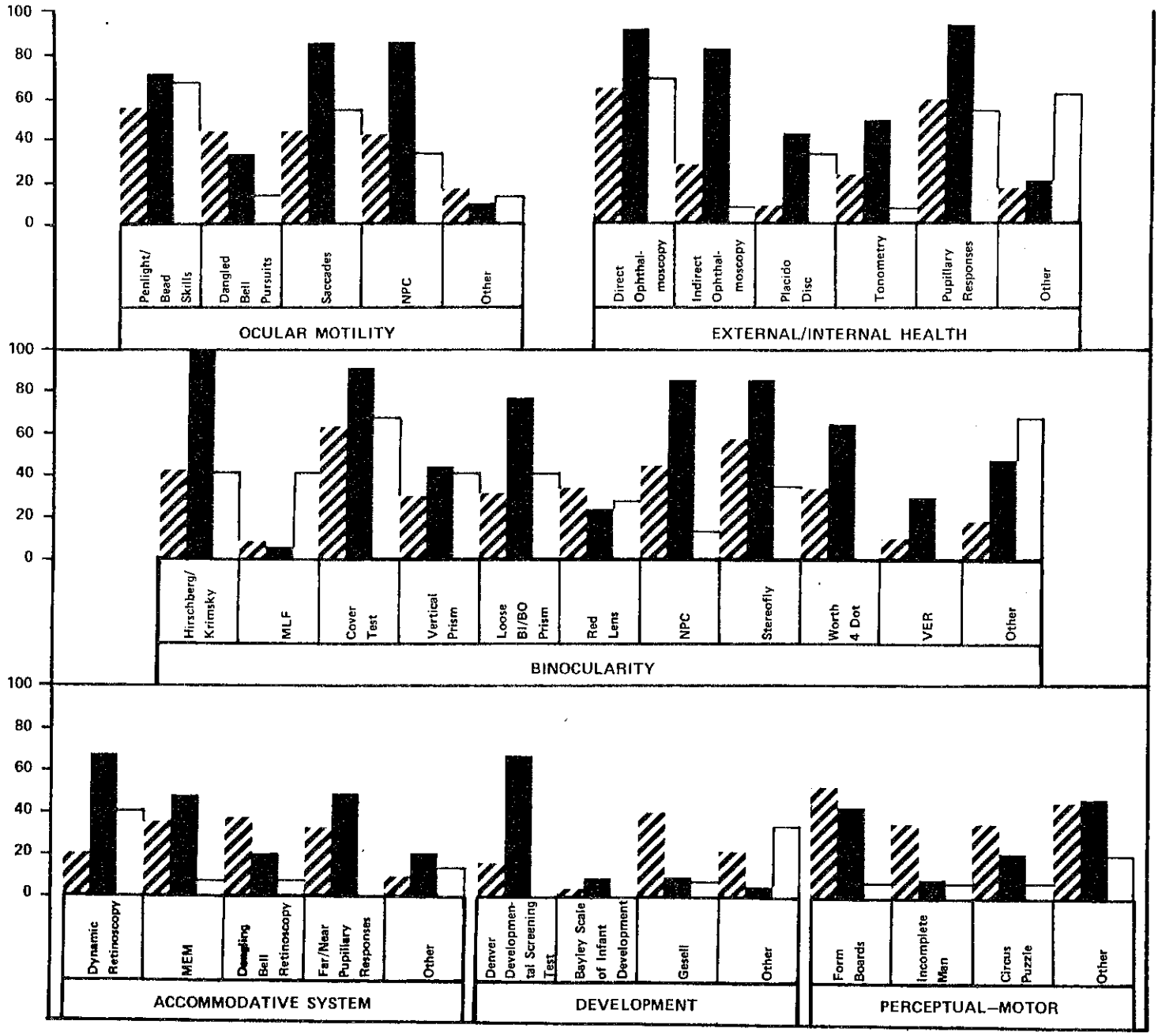
In examining the "other" columns in Figure 1 pertaining to each performance area, several of the percentages appear to be significantly high. However, it should be brought to the reader's attention that these values are inflated due to the fact that many write-in responses were given, but very few were specified more than once or twice. The following tests were written in by between five and ten participants: cycloplegic refraction, keratometry, Lighthouse acuity test, plus/minus lens flips, Randot, slit lamp or hand held slit lamp, confrontation fields, and size blocks.

The final question asked participants if a particular test sequence is followed. Forty-one percent of practicing optometrists use a particular sequence and 80% of instructors do. Not all of these responses were followed by a written description of the sequence, as was requested. Of those described, there was no consensus as to content or order of recommended tests.

Insert Table I and Figure I here.

PERFORMANCE AREA	Ranking	PRACTICING OPTOMETRISTS (A)	Percent	Ranking	INSTRUCTORS (B)	Percent
REFRACTIVE STATUS	1	Static Retinoscopy	53	1	Darkroom Retinoscopy	42.9
	2	Dynamic Retinoscopy	25.8	2	Darkroom Retinoscopy	28.8
	3	Dangling Bell Retinoscopy	24.2	3	Dynamic Retinoscopy	35.7
VISUAL ACUITY	1	Tumbling E	27.3	1	Preferential Looking	42.9
	2	Tumbling E	25.8	2	OKN/Preferential Looking/VER/Allen/Illiterate Chart	14.3
	3	Allen Picture Card	13.6	3	Bock Candy Bead	21.4
OCULAR MOTILITIES	1	Penlight/Bead Skills	51.5	1	Penlight/Bead Skills	57.1
	2	NPC/Penlight	24.2	2	NPC	35.7
	3	Saccades/NPC	25.8	3	Saccades	21.4
ACCOMMODATIVE SYSTEM	1	Dynamic Retinoscopy	48.5	1	Dynamic Retinoscopy	64.3
	2	Dynamic Retinoscopy	28.8	2	Dangling Bell	14.3
	3	Pupil Responses	16.7	3	Pupil Responses	7.1
BINOCULARITY	1	Cover Test	66.7	1	Hirschberg/Krimsky	64.3
	2	Hirschberg/Krimsky	18.2	2	Cover Test	28.6
	3	NPC	18.2	3	Loose BI/BO Prism	42.9
EXTERNAL/ INTERNAL HEALTH	1	Direct Ophthalmoscopy	83.3	1	Indirect Ophthalmoscopy	64.3
	2	Pupil Responses	60.6	2	Direct Ophthalmoscopy/Pupil Responses	28.6
	3	Tonometry	15.7	3	Pupil Responses	28.6
DEVELOPMENT	1	Gesell	56.1	1	Denver Developmental Screening Test	57.1
	2	Denver Developmental Screening Test/Gesell	7.6	2	Bayley	7.1
	3	Denver Developmental Screening Test	1.5	3	-	
PERCEPTUAL-MOTOR	1	Form Boards	59.1	1	Form Boards	50
	2	Circus Puzzle	22.7	2	Circus Puzzle	21.4
	3	Incomplete Man	16.7	3	Incomplete Man	7.1


100
90
80
70
60
50
40
30
20
10
0
Dynamic Retinoscopy
Darkroom Retinoscopy
MEM
Dangling Bell Retinoscopy
Static Retinoscopy
Automatic Refractor
Placido Disc
Other
REFRACTIVE STATUS
OKN
VER
Preferential Looking
Bock Candy Bead
Allen Picture Card
Stycar Acuity Test
Illiterate Chart
Tumbling E
Other
VISUAL ACUITY
PRACTICING OPTOMETRISTS (N = 105)
OPTOMETRY INSTRUCTORS (N = 21)
AUTHORS (N = 15)


100
80
60
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Penlight/ Bead Skills
Dangled Bell Pursuits
Saccades
NPC
Other
OCULAR MOTILITY
Direct Ophthal- moscopy
Indirect Ophthal- moscopy
Placido Disc
Tonometry
Pupillary Responses
Other
EXTERNAL/INTERNAL HEALTH
Hirschberg/ Krimsky
MLF
Cover Test
Vertical Prism
Loose BI/BO Prism
Red Lens
NPC
Stereofly
Worth 4 Dot
VER
Other
BINOCULARITY
Dynamic Retinoscopy
MEM
Dangling Bell Retinoscopy
Far/Near Pupillary Responses
Other
ACCOMMODATIVE SYSTEM
Denver Developmental Screening Test
Bayley Scale of Infant Development
Gesell
Other
DEVELOPMENT
Form Boards
Incomplete Man
Circus Puzzle
Other
PERCEPTUAL–MOTOR

Discussion

With so few optometrists seeing infants aged 0-3 years as indicated by the survey, one questions why. There are several hypotheses that can be considered: 1) the optometrist feels that a visual evaluation is not necessary until the child is older, 2) the optometrist is not familiar with tests that adequately assess the small child's visual system, therefore, she/he is not comfortable in working with an infant, and 3) she/he is not communicating effectively with the community and her/his patient population concerning preventative early eye care.

It is clear that there is agreement on the necessity for a child to have an exam early in life from the number of Doctors of Optometry and instructors who responded that a child's first vision exam should occur between birth and three years of age. It follows that not only do they express that the child should be seen early, but there is concurrence on which areas of visual performance need to be evaluated. Since these areas are comprehensive and comparable to those areas normally evaluated in both older children and adults, this substantiates the need for complete visual care to also include the youngster.

The second hypothesis proposed can be supported in part by examining the survey results (Table I - data from surveys answered with the proper ranking method) and by comparing and contrasting the information provided in Figure I. The data presented in Figure I shows the frequency a particular test

was denoted in the survey, indicating the amount a specific test is used by survey participants at one time or another. There are several ways in which this data can be interpreted. Low percentages could lead one to conclude: 1) that there is a lack of awareness or unfamiliarity of the test listed, 2) unavailability of specific equipment required for certain techniques, or 3) examiner bias to a certain test due to its effectiveness, validity, and reliability. Therefore, it is impossible to single out lack of awareness as accounting for the lower percentages in Figure I except as one contributing factor.

The responses given for tests of refractive status are quite informative and indicate a gap between new developments in the field and utilization of such information out in practice. Practicing optometrists selected static retinoscopy as the preferred technique to assess refractive status while instructors indicated darkroom retinoscopy as the most used technique. Mohindra's work has shown it to be an effective noninvasive method, providing results consistent with cycloplegic refraction.[18] Several articles concerning this technique and supporting its use have appeared in the literature.[5,14,19,20] However, when examining the specific sequences cited in the literature (Figure I) darkroom retinoscopy is seldom included with static retinoscopy given as the most common technique. The data points to evidence that this new retinoscopy technique, of all variations of retinoscopy, is not largely utilized by authors and practicing optometrists

alike. This data indicates the optometric community has apparently not received this information and is therefore unfamiliar with this latest technique. Also, this data might reflect their bias to static retinoscopy as a method in evaluating refractive error in infants. Perhaps due to infrequent patient population represented by infants, optometrists have not been able to utilize the Mohindra technique sufficiently so that they feel comfortable with it as a routine method. It requires minimal equipment (retinoscope and loose lenses) and does not depend on the use of cycloplegic drugs.

The area of visual acuity testing showed a difference between the two polled populations (Table I). Optometrists indicated that the Tumbling E test is the test of choice. This response is interesting and may be construed to mean a number of things, since even very few three year olds can respond reliably to such a symbol matching task involving directionality. The selection of Tumbling E may reflect the limited numbers of infants examined. In other words, practicing optometrists may not be presented with many opportunities to try different acuity test methods with infants or may not know of different testing options. The tests given top rankings by O.D.s (Tumbling E, Allen picture card) involve a complex matching task that is too difficult for the average 0-3 year old.[21,22]

Preferential looking has been shown to be an effective method for screening visual acuity of infants.[19,22-27] Instructors selected preferential looking as the primary method (Table I). This reflects the mode in which these optometrists practice, i.e., institutional setting with sophisticated instrumentation and access to the latest devices. This is further supported by data in Figure I which shows a great discrepancy in percent between instructors' responses and those of authors and practicing O.D.s. To suggest that practicing O.D.s incorporate preferential looking as a test method would not be feasible to many practitioners in view of expense versus patient population served. However, a preferential looking device can be constructed rather inexpensively, and could be cost effective for a practice seeing few infants, but wanting to provide such a service.[28] The fact that preferential looking is included infrequently in sequences in the literature (6.7%) further supports the authors observation that test sequences in the literature are not up to date.

For the optometrists who do not want to go to the trouble or expense of obtaining preferential looking equipment, several other acuity measurement methods are available. These methods generally involve less time and are more reliable than the Tumbling E method for ages 0-3 years.[29,30] The Bock candy bead test gives information regarding not only near visual acuity but eccentric fixation and hand-eye coordination as well. Instructors ranked this method third, which is understandable due to their access to more reliable and sophisticated

methods. The instructors gave the following tests as their second choice: OKN, preferential looking, VER, Allen picture card and the Illiterate chart. OKN is an easily administered technique, even though it is limited by not accurately quantifying acuity. By using this technique the practitioner can obtain some idea of the patency of the visual pathways.[16,30] Figure I points out a difference in utilization of VER by instructors as opposed to practicing O.D.s and authors, probably reflecting availability of electrodiagnostic equipment at optometry schools. Although VER is not practical in most practices due to expense, the technique should not be discounted where responses to other tests are questionable. In these cases, a referral for VER evaluation might be indicated.

Ocular motility testing responses were in agreement between practicing O.D.s and instructors. Both groups rank penlight pursuits, nearpoint of convergence and saccades as the three most used aspects of motility testing. Sequences in the literature also support the use of these tests (Figure I). There is an agreement that these skills should be evaluated and differences arise primarily with respect to target variations and stressing creativity to maintain the child's attention.

Accommodative testing also showed a consensus among participants and a much narrower range of preferred tests. Both groups indicated dynamic retinoscopy as the primary test of accommodative ability. As can be seen in Figure I, the literature also supports dynamic retinoscopy as a recommended test.

MEM (monocular estimate method) is another valid and reliable method to evaluate the accommodative system of an infant. This method is easily performed on the youngster due to the fact that fixation is accomplished readily. It gives a great deal of information in terms of the magnitude and quality of the accommodative response.[20,31-33]

Responses regarding binocularity testing corresponded, since the cover test and Hirschberg/Krimsky were the two most used tests. There was a disagreement between the use of the cover test as the primary test to use with practicing optometrists indicating this test in rank number one and instructors indicating the Hirschberg/Krimsky test as most used. The authors of sequences in the literature prefer the cover test to evaluate binocularity (see Figure I). Both of these tests are valid and reliable ways of evaluating binocularity which is substantiated within the literature.[10,34] However, in terms of maintaining fixation the cover test may prove to be more difficult with an infant whereas the Hirschberg/Krimsky test is an easily administered method where fixation does not need to be maintained as long. The low percentages of practicing O.D.s selecting the Hirschberg/Krimsky test may indicate a lack of awareness of this test or a bias to the cover test (see Table I).

In the area of external/internal exam there is relative concurrence between the two surveyed groups. Practicing optometrists are not using indirect ophthalmoscopy as frequently as are instructors. This may be due to lack of

equipment on the part of the practitioners. The increased field of view provided by the monocular indirect is a great benefit during the limited viewing time involved in infant ophthalmoscopy. Both groups stressed the importance of testing pupillary responses. Confrontation fields were rarely indicated in the survey and appear infrequently in sequences in the literature. However, it is a helpful screening method to rule out gross field defects. Also, important information is gained regarding the infant's fixation ability.

Developmental and perceptual-motor techniques are rarely included in infant test sequences in the literature. Practicing optometrists are more likely to follow the Gesell developmental guidelines while instructors utilize the Denver Developmental Screening Test to assess infant development. There are many other different methods of evaluating child development, however most cannot be used for the younger age group. The DDST is a valid and reliable test to assess development.[20] In view of the infant's limited capacity to respond, the DDST is an effective and efficient screening method. Tests of perceptual-motor ability have limited use with patients aged 0-3 years. However, for older infants within this age range, form boards and size blocks can provide useful information regarding perceptual and motor skills.[9]

Regarding the third hypothesis which proposed that the optometrist is not effectively communicating with her/his patient population and community about early vision care, the authors have no data which can support or refute it. However,

the lack of communication in educating the public as to the importance of preventative early vision care surely has an effect on the number of infant patients seen in a practice. For the optometrist wishing to broaden the scope of her/his practice to include infants many avenues are available through which to educate parents and members of the community. Examples include direct communication with parents and expectant parents, birth congratulations accompanied by relevant educational material, waiting room literature, information on preventative vision care included in your newsletter, speaking at PTA and other community organizations, etc. The optometrist may have the interest and skills necessary to examine infants, but without effective communication skills, this aspect of the practice cannot flourish.

Summary

Supported by the literature and based on survey results from optometric educators and practicing optometrists, the authors propose the following battery of tests within each performance area which can be utilized to adequately evaluate the child age 0-3 years.

REFRACTIVE STATUS:	Darkroom retinoscopy and/or Static retinoscopy combined with cycloplegia
VISUAL ACUITY:	Preferential looking and/or Bock candy bead and/or OKN
OCULAR MOTILITY:	Penlight pursuits and rotations Saccades NPC
ACCOMMODATION:	MEM (Monocular Estimation Method) and/or other Dynamic retinoscopy
BINOCULARITY:	Cover test and/or Hirschberg/Krimsky NPC Loose BI and BO prism
EXTERNAL/INTERNAL HEALTH:	Gross observation Direct/indirect ophthalmoscopy Pupillary responses Confrontation fields
DEVELOPMENTAL:	Gross observation Denver Developmental Screening Test and/or Gesell developmental guidelines
PERCEPTUAL MOTOR: (where applicable)	Form boards Size blocks

A point to be stressed is that flexibility within this battery is important, and the order in which tests are administered will depend on the infant's personality and behavior at the time.

Testing will be facilitated by examining the child at a time where maximum cooperation is most likely. Since every child is different it may be best to consult with the parent on what time of day would be appropriate.

It is not within the scope of this paper to expound on how to perform specific tests or what to expect as normal findings of these individual tests for specific age groups. Reference can be made to several works on infant vision testing.[20,30,35-39]

Now that the optometrist is well equipped with an up to date and reliable test battery for infants she/he can feel comfortable in broadening her/his scope of practice to include this select patient population. The public should be made aware that optometry is keeping pace with the trends and is a continually expanding profession. Optometry is challenged now more than ever to offer preventative health care services due to public awareness and research which has indicated critical periods in vision development.

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