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VISUAL PROFILE OF A RURAL

ELEMENTARY SCHOOL

POULATION

By

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Abstract

Three hundred twenty one children in the 4th through 8th grades were subjected to a comprehensive vision screening. The screening incorporated traditional methods such as visual acuity testing, and additional tests of binocular vision skills, eye movement and visual-perception. It was anticipated that this screening battery would identify more children with a visual deficit than would a screening with Snellen acuity testing alone. The results confirmed this, with more students failing the perceptual and eye movement aspects of testing than any other. Perceptual and eye movement testing may be a method of identifying more children with potentially troublesome deficits in these areas in the context of a school vision screening regimen.

Visual Profile of a Rural Elementary School Population

Introduction

The goal of this study was to determine the visual profile of students at an elementary school using not only traditional screening tests such as distance and near acuity but also incorporating an assessment of binocular vision functions including eye movement and perceptual tests. It was anticipated that the addition of these tests to a school screening regimen will uncover more students with deficient visual skills than would be found using traditional screening testing alone. The results generated from this battery of tests could be used to estimate the percentage of students in this population at risk for academic underachievement secondary to inadequate visual skills. The results will also help determine which areas of the students' visual profile show the highest percentage of problems. This will allow more efficacious screening batteries to be designed and administered, with a goal of having more children being directed for appropriate professional remediation.

Traditionally school nurses, volunteers, and various health care professionals have performed school screenings within the school systems. Often times school screenings are limited to distance visual acuities which are used as the sole indicator of a child's visual status. This unfortunately is only a small piece to the complex puzzle that makes up the visual system. With the fast paced and demanding environment that is encountered in the elementary school curriculum the visual system is a vital component that contributes significantly to the academic success of a child. The American Optometric Association recommends vision examinations for each child at 6 months, 3 yrs, and before the child enters school (1). Unfortunately, without widespread parental/guardian compliance to this recommendation the only way to discover many students with vision problems may be through a school vision screening program .

Snellen testing to determine visual acuity is not wide-ranging enough to discover all children with visual problems that could lead to trouble in school. One study showed that only 35% of students with a visual deficiency of some kind will test positive on snellen acuity screenings(2). In a literature analysis which compared visual acuity to reading success, it was determined that distance visual acuity is not related to reading performance, except possibly in the early grades. However, there is some evidence that indicates a relationship between reduced near acuity and poor reading ability.(3) Based on distance and near visual acuity tests alone one could easily predict the myopes, astigmats, and high hyperopes would fail this screening test. Therefore they would be properly referred for a comprehensive vision examination. But the low hyperope, emmetrope, or corrected ametrope would likely pass the distance and near visual acuity screening tests, but may have an eye movement, visual perceptual or binocular vision problem. Disorders of vision efficiency are estimated to be present in 15 to 20 percent of the school-age population (1).

The prevalence of myopia greater than or equal to –0.50 in the population of 6 to 18 years has been reported to be 20%. Also given that the prevalence of hyperopia greater than or equal to +1.50 has been reported to be 23%.(4) This leaves over half of the population of children between the ages of 6 to 18 who would pass the basic acuity screening test. Therefore it is imperative that a well-designed screening program be given to all students, which can assess a broad range of visual skills, each of which are important to academic and reading performance. Furthermore it is vital that these periodic evaluations of vision be performed throughout the school years, because it has already been determined that vision problems occur in a predictable pattern shown by prevalence studies in the past. For example, the incidence of myopia in the school age population has been determined to be the greatest around the ages of 8 to 10 and ages 14 to 16.(5) It would be appropriate to screen children at these age groups and ideally even before they reach these ages, to determine those who are in need of proper optical correction, even screening patients who have passed all testing previously. National reports of vision problems between the ages of 5 to 14 that require professional treatment range from 20%-25%. This number increases to 30% for children between the ages of 15 to19.(6)

Optometrists have been pushing recently to make advancements in the quality and content of vision screening at schools. Focus has been directed on efforts to mandate that all children be given a comprehensive vision examination by an eye care professional prior to entering school and periodically thereafter, much like children are required to pass dental and physical examinations.(6) The New York State Optometric Association has developed a screening battery which screens those visual skills that are deemed necessary to tasks specific for academic success. Optometrists who specialize in pediatric and vision therapy designed the battery. The design team felt that the battery would be more relevant if the unique perspective of reading and curriculum specialists, school psychologists, and a statistician were also incorporated into the design of the battery.

The NYSOA screening battery was developed with several goals in mind. The goals included: testing clearly defined visual skill areas, tests that would be cost and time effective, clear criteria for pass and fail, and effective administration by staff with minimal amount of training could be employed. Areas tested in the NYSOA battery are: distance and near acuity, hyperopia detection, accommodative facility, near point of convergence, Keystone telebinocular skills, stereo testing, eye movements, and perceptual testing. Distance acuity screens for myopia, high astigmatism, ambyopia, and high hyperopia. Near visual acuity screens for high refractive error and focus dysfunction. Mild hyperopia is screened for using the +1.50 sphere and a visual acuity test at 20 feet. Accommodative facility is tested for using the +/-1.50 flippers. Bell push-up was used to check convergence ability. Suppression, fusional ability, muscle balance, and color vision are assessed using the Keystone Telebinocular. The Titimus Stereo test is used to check binocularity and stereopsis perception. Eye movements are assessed using the NYSOA King Devick saccadic eye movement test. And finally the Winterhaven Copy Form tests are used to check eye-hand coordination, visual motor coordination, visual organization, and form reproduction.(4)

From a pre-pilot study in 1980 using the NYSOA test battery, it was concluded that this screening battery was far more sensitive in detecting those youngsters who had a visual problem than just using the standard Snellen. Specifically it was found that if one relied solely on the Snellen alone as a screening tool that it would only find one out of three youngsters who actually had a vision problem. Thus giving two out of three children a false sense of security as compared to the NYSOA screening battery, which proved to be a far more sensitive indicator of visual problems .

The battery of tests used in the screening project that is the subject of this paper were very similar to the battery developed by the NYSOA. Both distance and near visual acuities were tested. Static retinoscopy was used to determine the refractive error of the students. The unilateral and alternating cover test and near point of convergence were tested. Stereoacuity was assessed using the Wirt Stereo test and Stereofly test. Accommodative facility was tested with +/-1.50 flippers. Eye movements were tested using the Developmental Eye Movement Test (DEM), which provides an objective measure of eye movements and ocular motor ability. It has been theorized that the DEM test design assesses eye movements that closely match that required for reading and thus is a useful indicator of reading ability.(7) The Beery Visual Motor Integration (VMI) Test was used to determine a child's ability to motorically copy geometric forms from visual stimuli. Studies have shown a high correlation between an individual's performance on the Beery VMI and the their academic achievement, thus serving as a useful tool to screen for children with learning difficulties (8). Finally ocular health was screened for using the direct ophthalmoscope.

Methods

Study Population

Second and Third year optometry students from the Pacific University College of Optometry conducted a three-day vision screening during the spring of 2001 at Vernonia Elementary School in Oregon. Vernonia is a small rural logging community with a population of approximately 2000 people located at the base of the coastal range in western Oregon. The sample population totaled 321 children ranging in age from 8 to 16.

The study was developed to generate current data regarding the visual profile of an elementary school population using a comprehensive screening battery, employing perceptual testing, eye movement, binocularity, and refractive error in addition to standard Snellen tests. The statistics generated regarding the visual conditions that were found to be most prevalent serve many important functions. Such statistics aid the clinician in the development of clinical hypothesis allowing one to focus attention on the conditions that will be most prevalent. Data of this nature also aid the clinician in appropriate design and examination strategies allowing for the most useful tests to be administered in an efficient examination sequence. Prevalence statistics are also vital in making appropriate treatment and referral decisions based on a child's visual deficit.

This study also proved to be invaluable to the students, parents, and school administration of Vernonia. Each student received a computer generated summary of their child's visual profile. The summary explained what tests were given, what skills each test screened for, and how the child did on each of the tests. Those who were in need of optometric services, as indicated by the report, could then take the report to an eye care professional. The school administration may also find the information regarding their children useful because it provided them with a tool to promote health care such as vision screening in the school system. It also educated them on the prevalence of visual problems within their school system, which contribute to the learning levels achieved by their students. Finally this screening provided a health care service that would otherwise not be available to this isolated rural community.

Vision screening, referral, and examination procedures

Distance visual acuity measures were determined by the use of the Good-Lite units, which displayed an illuminated Snellen chart at a distance of 3m (10 feet). Near visual acuity was measured with a standard Snellen card held at distance of 40cm (16 inches). The students were tested monocularly and binocularly. The fail criterion was set at visual acuity of 20/40 or worse.

Refractive error testing was conducted in a dimly lit room with a Good-Lite unit at approximately 2.1m (7 feet) to serve as a fixation target. The student was instructed to look at a letter several lines above threshold. Static retinoscopy was performed over a fogging lens of +1.50. Skioscopy racks were used to determine refractive error. Fail criteria for refractive error was +1.25 hyperopia of more, -0.50 myopia or more, and/or – 0.75 astigmatism or more.

Binocularity was determined using the unilateral and alternating cover test at both distance and near. The distance target was a Good-Lite unit and the patient was told to fixate a letter several lines above threshold. The near target was a fixation bead. Fail criteria was determined to be any tropia.

Convergence ability was determined using a fixation bead while tromboning towards and away from the patients nose. The results were recorded for both the fusional break and recovery values. Fail criteria was a break value greater than 6cm and/or recovery value greater than 10cm.

Sensory fusion and more importantly stereopsis was measured using either the Wirt Stereo test with Polaroid glasses or Stereofly test with Polaroid glasses. The examiner held the card to prevent any monocular clues from contaminating the measure. Fail criterion was set at a stereoacuity of 80arc seconds or less.

Accommodative facility was determined using a standard Snellen card and the +/- 1.50 lens flippers. The examiner placed the card on a table while the student flipped the lenses. Students were instructed to flip the lenses only when the letters were clear. This was conducted over the time period of two minutes. Fail criterion was determined to be 8 cycles per minute or less.

Eye movements were assessed using the standardized Developmental Eye Movement (DEM) test. Using the required protocol each student was timed on all three sections of the test after careful explanation of the testing procedure. Fail criterion included those who performed at the 25th percentile or below on the horizontal, vertical, and/or ratio divisions of the test.

Form discrimination and visual motor integration was assessed using the Beery Visual Motor Integration test. This copy form test of 24 geometric forms was administered using the standard rules for conducting and completing the copy form test. Groups of students were administered the test in a room which was proctored by an optometry student to be sure there was no discussion between test takers or erasing of work completed. The fail criterion was set at 1.5 years below the expected age of performance.

Ocular health was screened using the direct ophthalmoscope, checking for any signs of anterior or posterior anomalies or disease. The fail criterion was determined to be any evidence of ocular disease or abnormality.

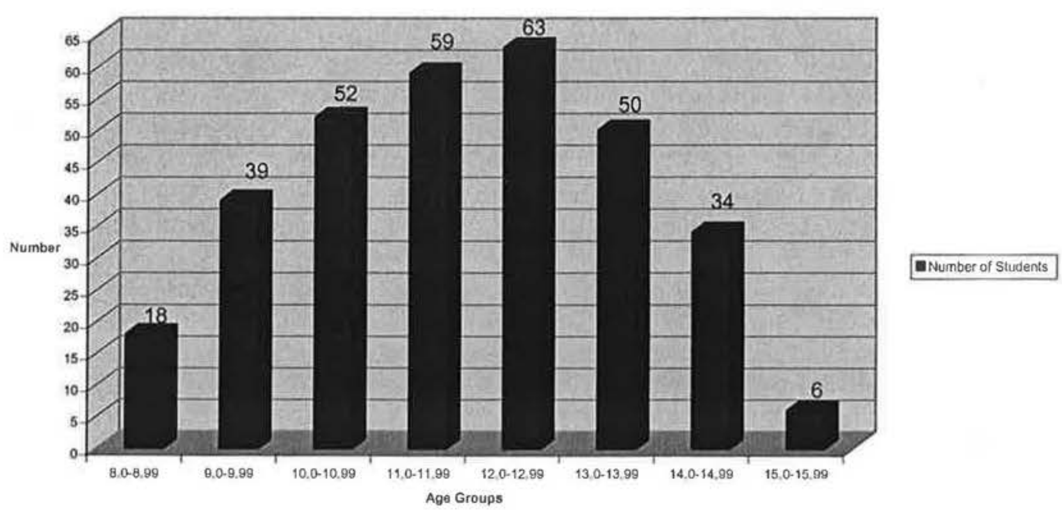
Data analysis

Three of the examination tests required calculations, scoring, and/or interpretations of the results. The accommodative facility test simply required the calculation of flips per minute. The DEM required the calculation of adjusted time scores, ratios, and percentile ranking. The Beery VMI was even more involved and time consuming because it required each copied form to be critically evaluated based on the form, the way that it was completed and it spatial orientation. Then one was required to assign a point score to each form and the total the points. Finally the total point score was compared to age expected scores thus giving the age performance score of the individual. Fortunately many of the students from the College of Optometry volunteered to tackle this tedious task. The data collected from the screening was entered into the Filemaker Pro database program. Some results were analyzed using this program, while other data was exported and analyzed with Microsoft Excel.

Results

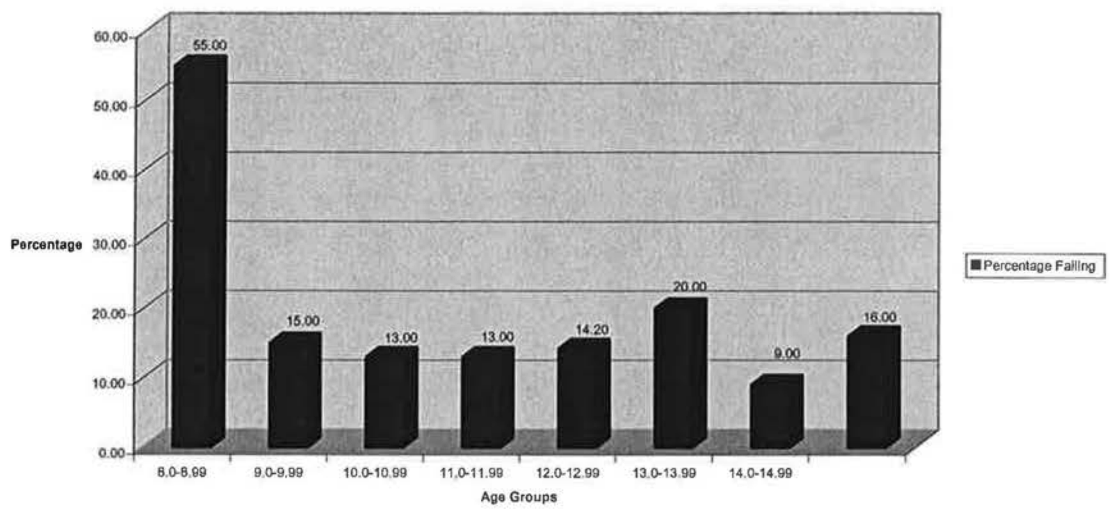
In descending order, the mean percentage of students failing each test area were: eye movements (56.16%), form discrimination-visual motor integration (39.34 %), two-eyed coordination (31.91%), refractive error (28.33%), near focusing ability (26.98%), distance acuity (19.40%), near acuity (6.50%), and ocular health (0.25%). The age distribution of screened children can be found in Figure I on the following page.

Figure 1: Student Age Breakdown



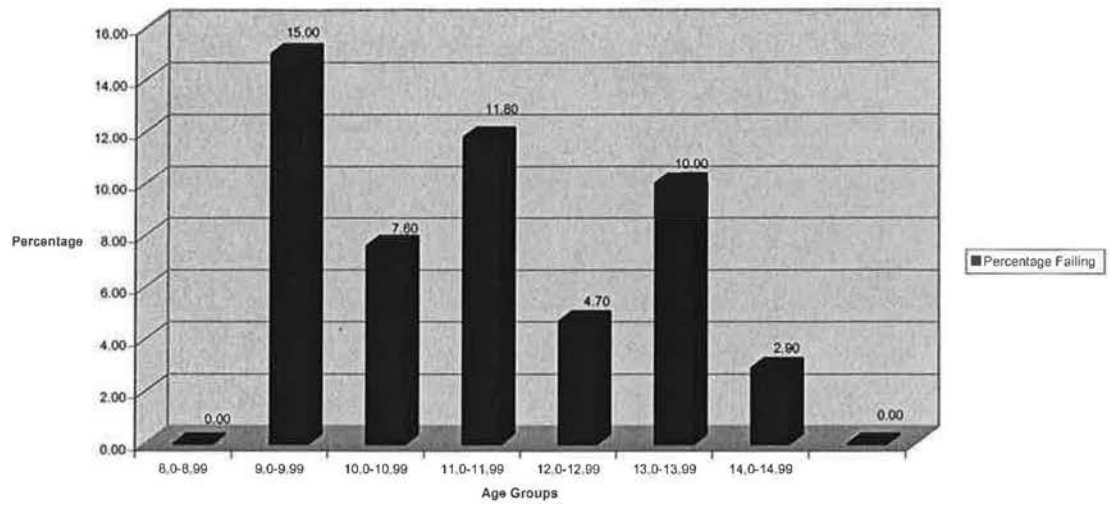
Grades 4 through 8 are represented, with the age groups ranging from 8.0 to 15.99 years, with an average age of approximately 11 to 12 years old. Figure 2 shows the percentage of students in each age group who failed the visual acuity test at distance. Except for the 8.0 to 8.99 age group, the number of students failing distance acuity was relatively stable throughout the age distribution.

Figure 2: Percentage Failing Sharpness of Far Vision Versus Age Groups



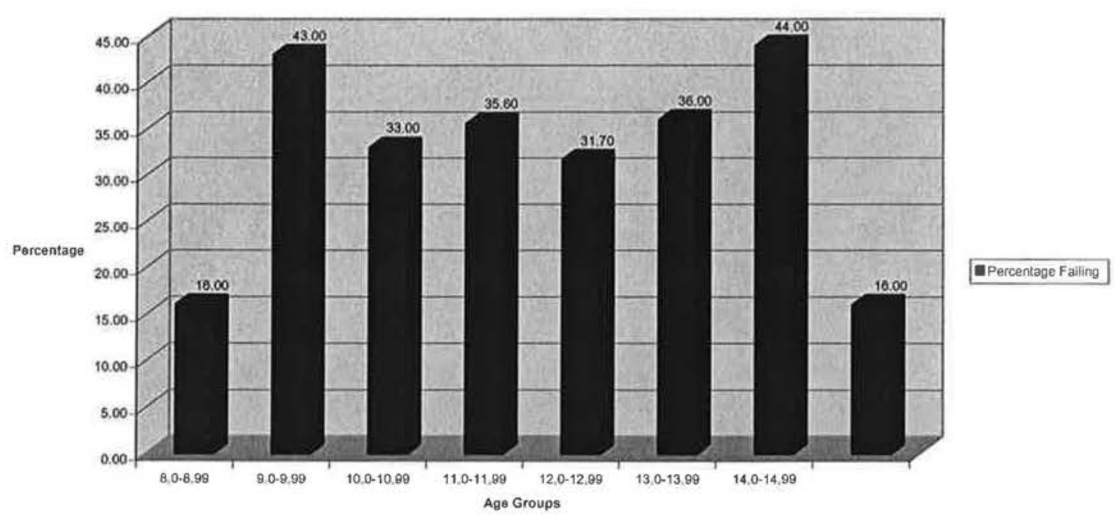
In contrast, Figure 3 shows that the percentage of students failing near acuity testing declined as the students became older.

Figure 3: Percentage Failing Sharpness of Near Vision Versus Age Groups



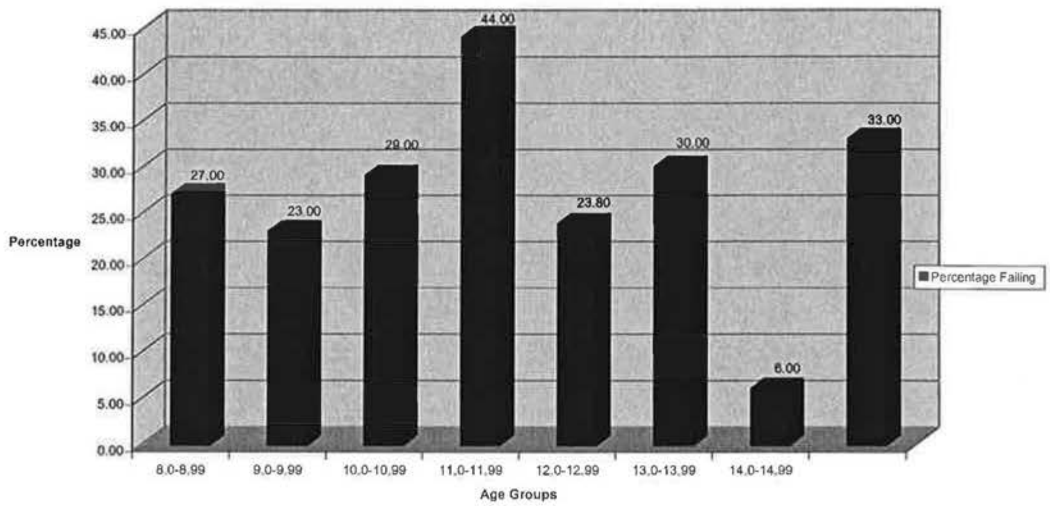
. Figure 4 shows the percentage of students who failed binocularity testing.

Figure 4: Percentage Failing Two-Eyed Coordination Versus Age Groups



Tests incorporated under binocularity testing included the distance/near cover test, stereo testing, and near point of convergence. Best-fit graphing demonstrates a relatively stable percentage of students failing at least one of the three binocularity tests utilized, with only the youngest age group (8.0 to 8.99 years) and oldest age group (15.0 to 15.99 years) having significantly fewer failures. Percentage of students failing accommodative facility testing is shown in Figure 5.

Figure 5: Percentage Failing Near Focusing Ability Versus Age Groups



On average the percent failing declines with increasing age in this population. Figure 6 illustrates the percentage of students failing the Developmental Eye Movement test. The number of students failing this test declines with increasing age.

Figure 6: Percentage Failing Eye Movements Versus Age Groups

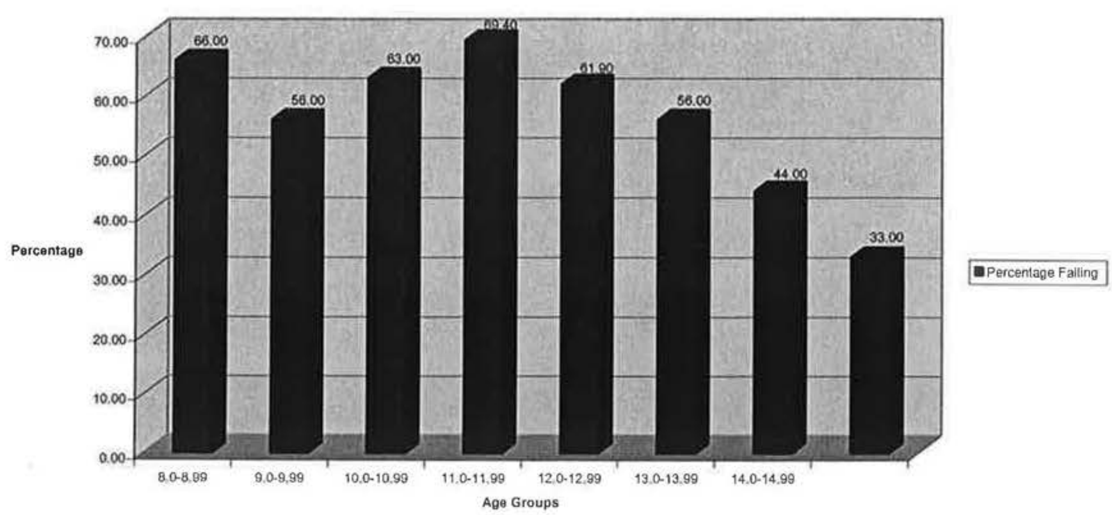
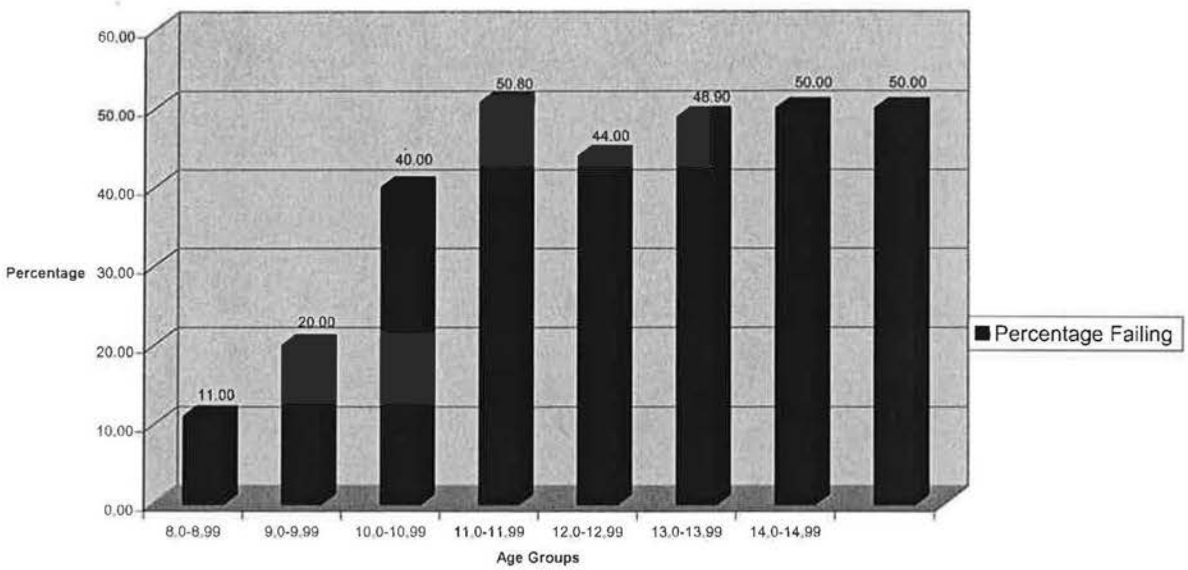


Figure 7 shows the percentage of students failing the Beery Visual-Motor Integration test.

Interestingly. the percentage failing increases as students become older, which is unexpected.

Figure 7: Percentage Failing Discrimination of Form Versus Age Groups



The percentage of students failing ocular health screening is seen in Figure 8. Only two students failed this aspect of the screening, both in the 9.0 to 9.99 age group.

Figure 8: Percentage Failing Eye Health Versus Age Groups

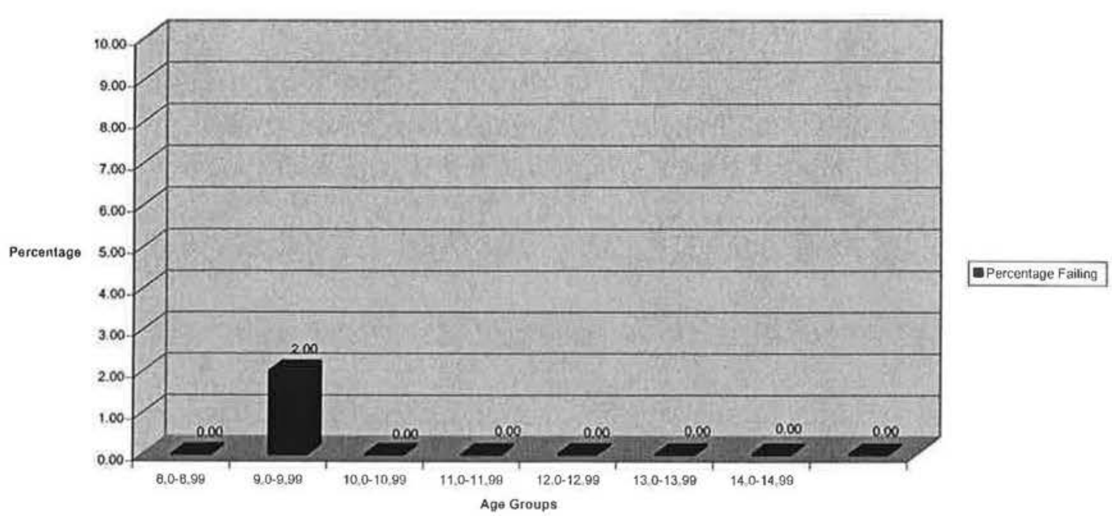


Figure 9 displays the percentage of students in each age group who passed all tests administered. This ranges from a high of 61.60% in the 8.0 to 8.99 age group to a low of 4.00% in the 13.0 to 13.99 age group. Only 34 students passed all tests.

Figure 9: Percentage of Students Passing All Tests Versus Age Groups

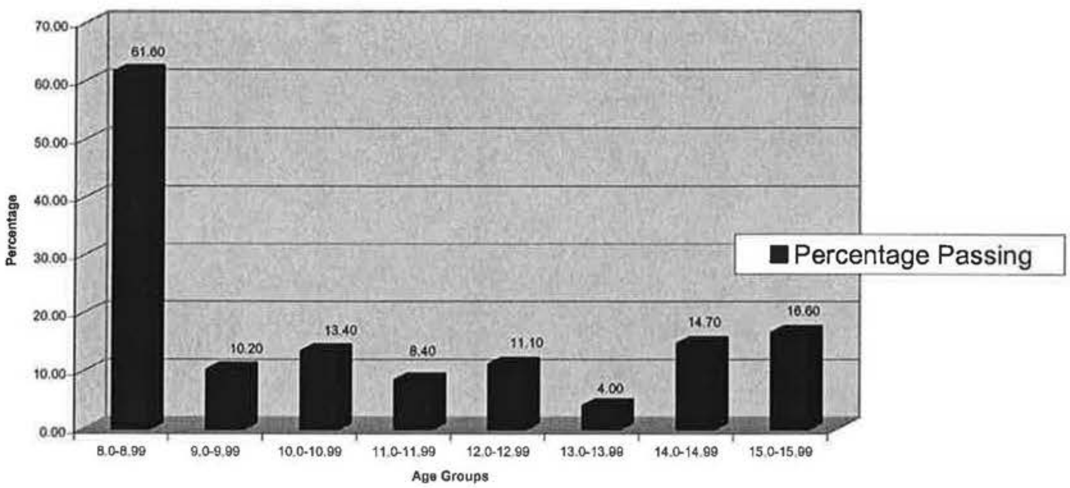
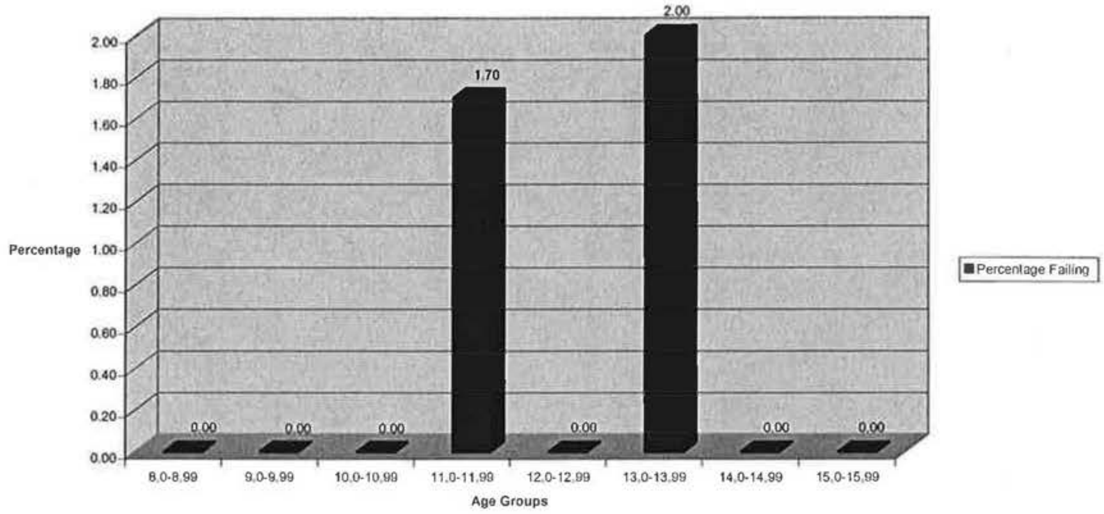


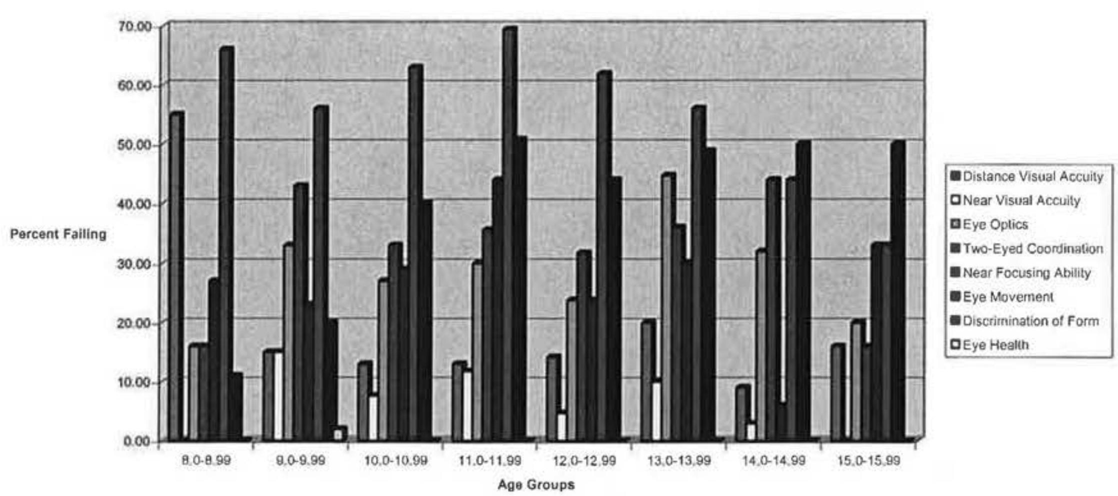
Figure 10 displays the percentage of students who failed all of the screening tasks.

Figure 10: Percentage of Students Failing All Tests Versus Age Groups



A summary of the percentage of students in each age group who failed each test area can be found in Figure 11.

Figure 11: Vernonia Screening Overview



Appendix I is a summary of the screening data (see next page). Age groups are plotted against the percentage of students in an age group failing a test area. Mean percentages failing in each test area are found at the bottom of the table. The mean, standard deviation, maximum and minimum of refractive errors, NPC break/recovery, accommodative facility, Beery VMI, and the DEM horizontal, vertical, ratio, and error scores are listed in Appendix II

Discussion

The results of the screening project clearly show that the visual skills most frequently found to be deficienct in this 4^{th} to 8^{th} grade student population are eye movement (56.16% failing), form discrimination (39.34% failing), and two-eyed coordination (31.91% failing). In descending order, the rest of the vision problems uncovered in this population were eye optics (refractive error measured with retinoscopy-28.33% failing), near focusing ability (26.98 % failing), distance visual acuity (19.40% failing), near visual acuity (6.50 % failing), and ocular health (0.25 % failing). Only 34 students out of 321 tested passed all test areas, while 2 students failed all tests.

Vision screening programs that test only one or a few of the above areas would create many false-negative results. Children who have a visual condition that could affect their ability to learn in school would not be spotted and managed accordingly. Many, if not most of the schools in the United States use only Snellen acuity testing in their vision screening programs (8). This type of screening does not accurately spot those students with binocularity problems, eye movement disorders, or visual-motor integration difficulties. Some students may be asymptomatic if they have vision or visual-perceptual problems that tend to discourage them from reading, or the child may simply not realize anything is wrong (9). A child manifesting any of these kinds of problems may have a higher probability of learning difficulty.

Studies have shown that there is a correlation between various types of deficient visual skills and reading problems (3, 10, 11). Near visual acuity, hyperopia, anisometropia, aniseikonia, convergence insufficiency, and fixation disparity have been found to be correlated to the incidence of reading problems in children. Stereopsis has not been definitively linked with reading deficiencies. Distance visual acuity was not found to be highly associated with reading problems, except in a student's first few years of school.

Dr. W. C. Maples explored the relationships between academic performance and several types of visual skills in a study of Oklahoma elementary school children (7). All of the tests utilized in the Vernonia school screening battery were assessed by Maples: near and far visual acuity, binocularity, accommodative performance, near point of convergence, Developmental Eye Movement test, Beery Visual Motor Integration test, and disease screening. He found that the Beery VMI test had the highest predictive value of a student's performance on a standardized reading test. The DEM ratio score was also found to be significantly associated with academic performance, though to a lesser extent than the Beery. He concluded that the best visual predictors of academic success are visual motor skills, visual-verbal skills (eg., the DEM vertical score), ocular-motor skills, and visual-perceptual skills. Refractive error and accommodation skills, while significant, were not as highly associated with reading performance. Other research has also shown that oculomotor deficiencies can in some cases hinder reading ability(11) , and that training perceptual skills can increase some childrens' ability to learn in an academic setting (12).

With this in mind it is readily apparent that the traditional vision screenings performed in many schools are inadequate in detecting a large portion of children who have a visual deficit that may limit or hinder their academic achievement. The data generated by this project further exemplifies the need for standardized screening batteries that will assess all aspects of a child's visual profile. Some children who "slip through the cracks" of traditional school vision screenings may have significant problems in school, and later in society. One study found that 66% of functionally illiterate adults failed at least one aspect of an optometric examination (13). In another study 74% of illiterate adults failed some aspect of an optometric examination. Harris found that 98% of a population of juvenile delinquents failed one or more aspects of a vision examination (14). Others have discussed the possible relationship between visual function, learning disability, and juvenile delinquency (16,17). While it cannot be said that there is a cause and effect relationship between deficient visual skills and illiteracy or juvenile delinquency, visual deficiencies may have a negative primary or secondary affect on the learning process. Learning problems related to vision deficiencies may then lead to behavioral problems, social problems, dropping out of school, and ultimately to a lack of success in society.

In recent years there has been a push by organized optometry to pass into the law of many states the requirement for all entering school children to have comprehensive vision examinations by an optometrist or ophthalmologist. These efforts are being supported by research showing the correlation between visual abilities and academic performance. In light of research by Maples showing the linkage of visual motor integration and eye movement skills to reading ability, it would be prudent to ask the question of whether or not these skills are being assessed in a normal comprehensive examination.

Visual acuity and other associated visual skills are important to a student's learning process. The ability to properly assess a student's performance in various visually-related tasks could be a critical factor in determining whether a student succeeds or fails in the school setting. The Vernonia screenings show that deficits in the areas of visual motor integration, eye movement skills, and eye teaming are more predominant that Snellen acuity or significant refractive error. More research is needed to determine what kinds of deficient visual skills have significant associations with academic performance. Students having such deficiencies can then be better targeted for remediation at an early time in their school career.

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Appendix 1: Vernonia Project - Percentages that Failed Screening

Age Group	Number	Sharpness of Far Vision	Sharpness of Near Vision	Optics of the Eye	Two-Eyed Coordination	Near Focusing Ability	Eye Movements	Discrimination of Form	Eye Health	Number Passing All	Percent Passing All	Number Failing All	Percent Failing All
8.0-8.99	18	55.00	0.00	16.00	16.00	27.00	66.00	11.00	0.00	3	61.60	0	0.00
9.0-9.99	39	15.00	15.00	33.00	43.00	23.00	56.00	20.00	2.00	4	10.20	0	0.00
10.0-10.99	52	13.00	7.60	27.00	33.00	29.00	63.00	40.00	0.00	7	13.40	0	0.00
11.0-11.99	59	13.00	11.80	30.00	35.60	44.00	69.40	50.80	0.00	5	8.40	1	1.70
12.0-12.99	63	14.20	4.70	23.80	31.70	23.80	61.90	44.00	0.00	7	11.10	0	0.00
13.0-13.99	50	20.00	10.00	44.80	36.00	30.00	56.00	48.90	0.00	2	4.00	1	2.00
14.0-14.99	34	9.00	2.90	32.00	44.00	6.00	44.00	50.00	0.00	5	14.70	0	0.00
15.0-15.99	6	16.00	0.00	20.00	16.00	33.00	33.00	50.00	0.00	1	16.60	0	0.00
Total	321									34		2	
Mean		19.40	6.50	28.33	31.91	26.98	56.16	39.34	0.25		17.50		0.46

Sharpness of Far Vision= Snellen acuity at distance
Sharpness of Near Vision= Snellen acuity at near
Optics of the Eye= Static retinoscopy
Two-Eyed Coordination= Cover test (near and far), near point of convergence (break and recovery), and stereopsis
Near Focusing Ability= Binocular accomodative facility
Eye Movements= Developmental Eye Movement (DEM) testing
Discrimination of Form= Visual Motor Integration(VMI)/ Beery testing
Eye Health= Anterior and posterior ocular health screening examinations

Appendix 2 Vernonia Project-Summary of Means, Standard Deviations, Maximums, and Minimums

	Ret Sph R	Ret Cyl R	Stereoacuity	NPC Brk	NPC Rec	Acc Fac Aver	VMI-AE	VMI-Adiff	Chrono Age	DEM-H%	DEM-V%	DEM-R%	DEM-ErSc%
Mean	0.35	-0.18	52.91	3.20	6.20	7.08	10.71	-1.13	11.82	43.69	44.49	47.46	57.11
Standard Deviation	1.17	0.40	75.15	5.50	6.90	4.17	2.58	2.60	1.77	29.31	29.93	32.75	35.80
Maximum	8.00	0.00	800.00	43.00	45.00	39.17	14.00	5.51	15.41	110.00	104.00	106.00	99.00
Minimum	-5.00	-4.00	20.00	0.00	0.00	0.00	4.10	-13.96	7.82	1.00	1.00	1.00	0.00