# Optometric Screening of Elementary Students in Greece

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### Authors' contributions

*This work was carried out in collaboration between both authors. Author MBL designed the study, performed the statistical analysis and wrote the protocol. Author AC wrote the first draft of the manuscript. Authors MBL and AC managed the analyses of the study and the literature searches. Both authors read and approved the final manuscript.*

### Article Information

| **Short Research Article** |
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## ABSTRACT

**Background:** The aim of this study is to provide a wide screening test in elementary school students in Greece in order to trace undiagnosed visual deficiencies, which can affect the visual performance and efficiency.

**Methods:** Examination procedures were approved by the Ministry of Education for the optometric team to enter the school premises and perform the assessments. The researchers performed optometric testing according to standard protocols to evaluate visual acuity (VA), near point of convergence (NPC), accommodative amplitude and facility, vergence facility, stereopsis, and pursuit and saccade oculomotor function.

**Results:** The 835 students that were examined came from a total number of 14 schools so as to enable social stratification of high, medium, and low living standards. Fewer than 17% of the children managed to pass all visual tests at published goal levels. Testing identified a significant number of students who had undiagnosed visual deficiencies (83%).

**Conclusion:** Visual Function in elementary students needs to be evaluated on a regular basis following a comprehensive Optometric screening so that a wide range of visual dysfunctions can be

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detected. Our ultimate goal is to ensure adequate conditions for every student to develop vision skills needed to meet academic demands.

*Keywords: Optometry; vision; visual dysfunctions; visual skills; vision screening; vergence; accommodation; ocular motility.*

## 1. INTRODUCTION

Clinical experience has identified a high number of previously undiagnosed visual dysfunctions in school-aged children in Greece presenting for care. Although optometric screening is a common and approved primary care in most countries all over the world, in Greece it has not been integrated as a standard of care [1].

### 1.1 Visual Screening

According to the existing regulations in Greece, every child who enters elementary school must have a visual examination performed by an ophthalmologist. During the examination, the ophthalmologist investigates the visual health, the ophthalmic structure integrity, the visual acuity, and refractive error. Based on the findings the doctor may proceed to the prescription of eye lenses for improving eyesight. The current eye testing in Greece does not involve all the spectrum of functional visual performance evaluated with a wide range of optometric tests [2].

## 2. METHOD

The research took place in Greece, a few months before the covid-19 pandemic and was abided by the tenets of the Declaration of Helsinki and followed published test administration protocols [1,2]. All participated students had prior written instructions to bring with them, the day of examination, any type of glasses or other vision aid they use. Students in 4th grade (10 years old) and 6th grade (12 years old) were enrolled in the study because they should have passed at least 2 eye exams prior to functional vision screening. The vision assessment evaluated visual acuity (VA), near point of convergence (NPC), accommodative amplitude and facility, vergence facility, stereopsis, and pursuit and saccade oculomotor function.

### 2.1 Visual Acuity Testing

Visual acuity (VA) is a direct measure of the clarity of eyesight. A Snellen optotype chart consisting of numbers and graded from 1/6 to 6/6 was viewed at a testing distance of 6m and under correct lighting standards of the chart used. The examination was completed with habitual lens correction (with glasses or without glasses if not worn). Visual acuity was recorded as the line in which more than 50% of the numbers were identified. Each eye was tested separately and then binocular visual acuity was also recorded. Visual acuity was expected to be equal or better than 20/25 to pass this assessment. A difference between the two eyes should also not be greater than one line [3].

### 2.2 Near Point of Convergence Testing

In order to examine near point of convergence (NPC) skill, the student was instructed to maintain gaze as a Wolf wand target was brought toward the nose. The fusion break was recorded at the distance at which one of the two eyes no longer followed the target. The recovery point measurement was achieved by moving the target away from the subject's face and locating the point at which eye co-operation returned. The test is repeated several times in order to draw an average performance and a stable response. The published acceptable break point values are between 5 - 8 cm and recovery 8 – 11 cm, [4,5,6]. The acceptable break point for this study was set to under 8cm and the acceptable recovery under 11cm [7].

### 2.3 Accommodation Testing

The amplitude of accommodation is defined as the maximum dioptric change in the power of the crystalline lens a subject can achieve. Accommodation facility assesses the ability to quickly acquire clear and distinct image. In this research we tested the ability of each individual to change focus between +/-2.00 D lenses known as accommodation flexibility. Every child sat on a chair at a slanted desk with a 20-degree tilt and a viewing distance of 40 cm to control for accommodative and vergence demand. Accommodative Rock cards with words were used as targets. As the student cleared the print and accurately read the words correctly on the testing card, the examiner changed the position of flipper lens. A full cycle is considered by

changing the flipper to view through +2.00 and -2.00. When time reached 1min, the assistant stopped the procedure and number of cycles was recorded. First Binocular Accommodation Facility (BAF) was executed and then Monocular Accommodation facility (MAF) testing was completed. Passing criteria was set at 5 cycles per minute (cpm) Binocular and 7 cpm Monocular [8,9,10,11].

## 2.4 Vergence Facility Testing

The flexibility of moving the eyes between convergence and divergence posture was tested with a prism flipper consisting of $3^\Delta$BI /$12^\Delta$BO and targets at 40cm from the examinee. Every child sat on a chair at a slanted desk tilted 20 degrees to control for stable accommodation and vergence demand. Accommodative Rock cards with words were used as targets and viewed through one side of the $3^\Delta$BI /$12^\Delta$BO prism flipper. When the student recognized the one

word correctly without double vision, the flipper was altered. A full cycle considered by changing the flipper to view through both $3^\Delta$BI and $12^\Delta$BO prism. When time reached 1min the assistant stopped the procedure and number of cycles was recorded. The minimum requirements for normal facility between convergence and divergence operation were set at 15 cycles per minute (cpm) [12].

## 2.5 Stereopsis Testing

A Random Dot 3 Stereo test was administered using Polarized glasses and examination distance of 40cm in photopic conditions. The examinee was asked to wear the polarized glasses and look at the stereoscopic test. Shapes should be recognized in response of various stereoscopic objects starting at a disparity of 600 sec arc and down to 12.5sec arc. The maximum stereoscopic acuity of the examinee was recorded [13].

| A/A | PURSUIT EYE MOVEMENT | | | | SACCADES EYE MOVEMENT | | | |
|---|---|---|---|---|---|---|---|---|
| STUDENT | ABILITY | ACCURACY | HEAD MOV. | BODY MOV. | ABILITY | ACCURACY | HEAD MOV. | BODY MOV. |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |

**Fig. 1. Recording form for NSUCO test results**

**Table 1. Pass/Fail Criteria**

| Fail Test Criteria | | | |
|---|---|---|---|
| Visual Acuity (VA) | ≤20/25 | Within 1 line | monocular |
| | ≤20/25 | | binocular |
| Near Point of Convergence (NPC) | < 8cm (break) | | <11cm (recovery) |
| Accommodative Facility | >5 cycles per minute (cpm) (monocular) | | > 3 cpm (binocular) |
| Vergence Facility | ≥12 cpm | | |
| Stereo Acuity | ≤ 50 sec of arc | | |

**Table 2. NSUCO Minimum Expected Values**

| A/A | Pursuit Eye Movement | | | | Saccade Eye Movement | | | |
|---|---|---|---|---|---|---|---|---|
| Student | Ability | Accuracy | Head Mov. | Body Mov. | Ability | Accuracy | Head Mov. | Body Mov. |
| 4th Grade Boys | 5 | 4 | 4 | 4 | 5 | 3 | 3 | 4 |
| 4th Grade Girls | 5 | 4 | 4 | 5 | 5 | 3 | 3 | 4 |

| A/A | Pursuit Eye Movement | | | | Saccade Eye Movement | | | |
|---|---|---|---|---|---|---|---|---|
| Student | Ability | Accuracy | Head Mov. | Body Mov. | Ability | Accuracy | Head Mov. | Body Mov. |
| 6th Grade Boys | 5 | 4 | 4 | 4 | 5 | 3 | 3 | 4 |
| 6th grade Girls | 5 | 4 | 4 | 5 | 5 | 3 | 4 | 5 |

## 2.6 Pursuit and Saccade Oculomotor Testing

The purpose of the oculomotor test is to evaluate the quality and accuracy of pursuit eye movements and saccadic eye movements. A smooth pursuit describes a type of eye movement in which the eyes remain fixated on a moving object. A saccade is a quick, simultaneous movement of both eyes between two or more phases of fixation in the same direction. The North-eastern State University College of Optometry (NSUCO) test was used to evaluate the performance of students in oculomotility [14].

An examiner holding the 10mm diameter fixation target at a distance of 40cm from the examinee was assessing accuracy and ability scores according the NSUCO testing protocol conducted oculomotor testing. Behind and next to the examiner, a second observer objectively evaluated body and head movements. The instruction to the examinee was "follow the target as if your eyes were connected to it with an invisible rope." The examiner performed two counterclockwise circles 20cm in diameter and then two clockwise circles of the same diameter to assess pursuit oculomotor function. Saccadic oculomotor testing was completed with two stationary targets of 5 mm in diameter and the student alternated gaze between the two targets.

Evaluation of performance was made following the published test instructions and included scoring four areas: ability, accuracy, amount of head movement and the amount of body movement. The results were recorded in special forms shown in Fig.1.

## 2.8 Pass/Fail Criteria

In order to evaluate the performance of each individual, the criteria were set to determine the pass/fail performance on each functional vision test. Tables 1 and 2 show the minimum accepted values for passing each assessment.

NSUCO norms for children of 4th and 6th are shown on Table 2 [15].

## 3. RESULTS

### 3.1 Quantitative Demographic Characteristics

The total number of examined students in the research study was 847. Twelve (12) students were excluded due to eligibility based on not being enrolled in the education system, inability to speak fluent Greek, or inability to perform the optometric tests. A total of 835 students were able to complete the study as described in Table 3. Data was collected on 188 4th grade boys, 217 4th grade girls, 197 6th grade boys, and 233 6th grade boys.

**Table 3. Study Participant demographics**

| | Boys | Girls | Total |
|---|---|---|---|
| **4th Grade Students** (mean age 10 years old) | 188 (46%) | 217(54%) | 405 |
| **6th Grade Students** (mean age 12 years old) | 197(46%) | 233(54%) | 430 |
| **Total** | **385** | **450** | **835** |

**Table 4. Social Stratification of Study Participants**

| Living standards | Number of students |
|---|---|
| HIGH | 198 (23.7%) |
| MEDIUM | 313 (37.4%) |
| LOW | 324 (38.8%) |

The 835 students evaluated during the study came from a total number of 14 schools. In order to have the most representative sample of the social stratification, schools were selected to be located in areas of high, medium, and low living standards as described in Table 4. Of these schools, 3 were located in areas of high standards of living (198 students), 5 in areas of medium standards (urban areas) (313 students) and 6 in areas of rather low standards of living (324 students). Authors did not find any difference in students' performance of schools in high-standard and urban areas. As a result, in this study living standard analysis is redundant.

## 3.2 Analysis of Test Results

The total number of enrolled study participants was 835. 143 students passed all tests areas. 692 students failed at least in one test. This identified that 82.9 % had reduced visual performance as shown in Figure 2.

Dividing students between 4th and 6th grade students, 356 (90.4%) students of 4th grade failed in screening test and only 39 (9.6%) passed. In 6th grade students, 326 (75.8%) failed a visual screening test and 104 (24.2%) passed all areas of visual performance assessment. More than 3 of 4 students failed passing the screening test as shown in Figures 3 and 4.

## 3.3 Analytical Findings in Optometric Screening Tests

Table 5 demonstrates details of how students performed in every test. In the Visual Acuity test,

755 students (90.4%) passed by correctly reading 20/25 sized numbers at 6m. Only 80 students (9.6%) were found to have reduced acuity. Reduced VA was found in 18 boys and 19 girls of 4th grade and 16 boys and 27 girls of 6th grade. The largest percentage of students who failed this test was due to a measurement of reduced monocular acuity (64 students - 80%).

Near Point of Convergence testing resulted in 584 (69.9%) students passing and 251(30.1%) failing to convergence accurately. Those who failed were 62 boys and 78 girls from the 4th grade and 49 boys and 62 girls from the 6th grade.

In Accommodation Facility testing, 444 (53.2%) students passed and 391 (46.8%) failed. Those who failed were 94 boys and 131 girls of the 4th grade and 77 boys and 89 girls from 6th grade.

The Vergence Facility test was completed at a passing level by 581 (69.7%) and failed by 254 (30.3%) of the students. Of those who failed, 161 were 4th grade students, including 61 boys and 100 girls. Of the 6th grade students, 93 failed, including 43 boys and 50 girls.

In the stereo acuity test, 707 (84.7%) students passed and 128 (15.3%) failed. Testing identified reduced stereopsis ability in 32 boys and 44 girls of 4th grade and 21 boys and 31 girls of 6th grade.

In the NSUCO oculomotility test, only 368 (44.1%) students passed and 467 (55.9%) failed. Those who failed were 132 boys and 143 girls of 4th grade and 99 boys and 93 girls of 6th grade.
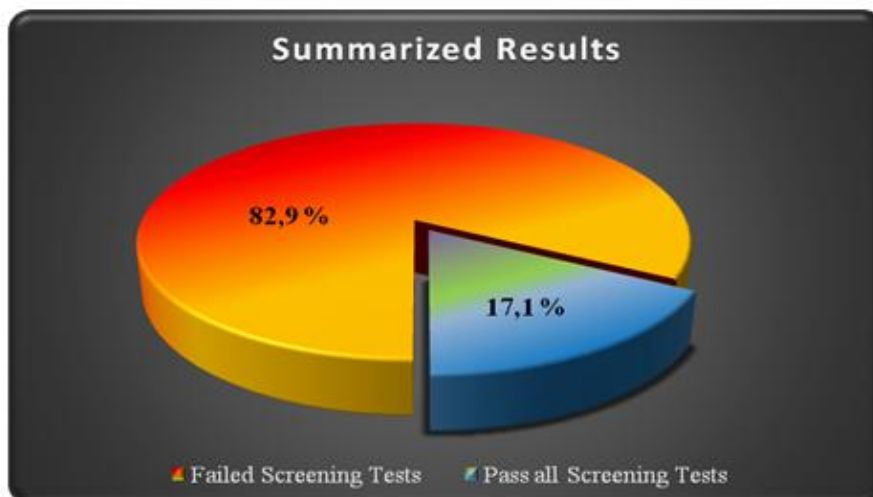


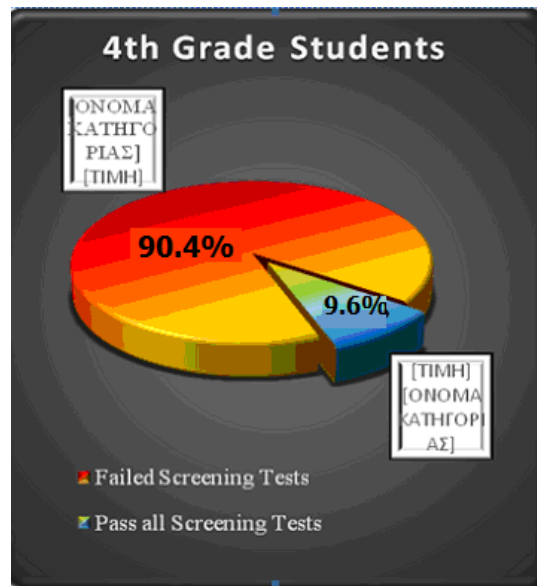**Fig. 2. Graph showing pass/fail rate of visual performance screening testing**

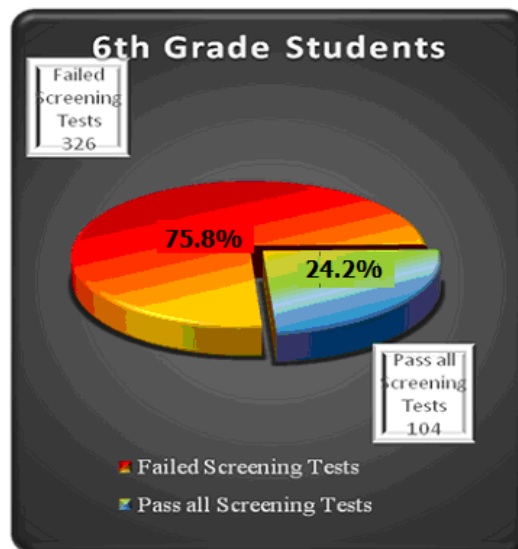**Fig. 3. Graph of failed/passed visual screening testing in 4th grade students**



**Fig. 4. Graph of failed/passed visual screening testing in 6th grade students**

**Table 5. Total number of students who passed and failed vision testing**

| Test | Passed | Failed | 4th Grade FAILED | | 6th Grade FAILED | |
| | | | Boys | Girls | Boys | Girls |
|---|---|---|---|---|---|---|
| Visual Acuity | 755 (90.4%) | 80 (9.6%) | 18 | 19 | 16 | 27 |
| Near Point of Convergence | 584 (69.9%) | 251 (30.1%) | 62 | 78 | 49 | 62 |
| Accommodative Facility | 444 (53.2%) | 391 (46.8%) | 94 | 131 | 77 | 89 |
| Vergence Facility | 581 (69.7%) | 254 (30.3%) | 61 | 100 | 43 | 50 |
| Stereo Acuity | 707 (84.7%) | 128 (15.3%) | 32 | 44 | 21 | 31 |
| NSUCO test | 368 (44.1%) | 467 (55.9%) | 132 | 143 | 99 | 93 |

## 4. DISCUSSION

First of all, less than 1 in 5 children (17%) managed to pass all the areas of the functional vision examination process. That means, more than 4 in 5 students (83%) exhibit at least one visual restriction in their day living activities at school. These restrictions could be found in tracking visual information or focusing in a school task or changing focus between tasks. There could also be problems in converging or diverging from the board to the book and vice versa.

Consequently, a significant number of students were found to have undiagnosed visual problems. It is noteworthy that those students already passed at least one ocular examination but without being diagnosed with any visual problem. So, that leads us to the conclusion that visual acuity is only one part of the puzzle of their visual performance. A recent study (2020) from Avi Portnoy and Sharon Gilaie-Dotan [15], has proved the significance to examine other parts of visual function as oculo-motility rather than base our evaluation on Visual Acuity only.

Therefore, areas of oculomotor and binocular function were evaluated in this study. Further research should also include visual perception and sensory integration ability.

Accordingly, many school activities required functional vision skills performance as assessed in this study. Failure in the visual screening can identify students with poor fixation and increased number of regressions while reading, difficulties in looking at the chalkboard and back to the paper, as well as additional needed to focus and make text clear.

At last, the visual restrictions identified during this testing may cause delays in educational progress, academic stress, and disappointment causing the student to drop out school and the educational environment.

## 5. CONCLUSION

Visual acuity problems (eyesight) are resolved in the majority of students by the existing ophthalmology care in Greece. However, this research demonstrated that other visual skills have not been appropriately identified or addressed. Thus, comprehensive optometric examination must be included in a regular base throughout the educational years.

## CONSENT

As per international standard or university standard, Participants' written consent has been collected and preserved by the authors.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1.  Mazzone P. orcid.org/0000-0003-0944-8031, Carlton J. orcid.org/0000-0002-9373-7663 and Griffiths, H. orcid.org/0000-0003-4286-5371. Summary vision screening data: Greece. Report. Vision Screening Country Reports. EU Screen; 2018.
2.  2.Carlson, Nancy B, Daniel Kurtz. Clinical Procedures for Ocular Examination. 4th ed., McGraw-Hill Education, 2016;36-42.
3.  Carlson, Nancy B., and Daniel Kurtz. *Clinical Procedures for Ocular Examination*. 4th ed., McGraw-Hill Education, 2016;86-88.
4.  Scheiman, Mitchell, et al. Clinical Management of Binocular Vision*: Heterophoric, Accommodative, and Eye Movement Disorders*. Lippincott Williams & Wilkins; 2014.
5.  Lieberman, Steven, et al. "Validation Study of the New York State Optometric Association (NYSOA) Vision Screening Battery." Optometry and Vision Science. 1985;62(3):165–168. DOI:10.1097/00006324-198503000-00003.
6.  Maples, Willis C, Richard Hoenes. "Near Point of Convergence Norms Measured in Elementary School Children." Optometry and Vision Science. 2007;84(3):224–228., DOI:10.1097/opx.0b013e3180339f44.
7.  Mckenzie, kenneth M, et al. "Study of Accommodative Facility Testing Reliability." Optometry and Vision Science. 1987;64(3):186–194. DOI:10.1097/00006324-198703000-00005.
8.  Rouse, Michael W, et al. "Monocular Accommodative Facility Testing Reliability." Optometry and Vision Science. 1989;66(2):72–77. DOI:10.1097/00006324-198902000-00002.
9.  Scheiman, Mitchell et al. "Normative Study of Accommodative Facility in Elementary Schoolchildren." Optometry and Vision Science. 1988;65(2):127–134. DOI:10.1097/00006324-198802000-00009.

10. Rouse, Michael W. et al. "Binocular Accommodative Facility Testing Reliability." Optometry and Vision Science. 1992;69(4):314–319. DOI:10.1097/00006324-199204000-00010.

11. Cheiman, Mitchell, et al. Clinical Management of Binocular Vision: Heterophoric, Accommodative, and Eye Movement Disorders. Lippincott Williams & Wilkins. Section 1: Diagnosis and general treatment approach. 2014;40-41.

12. Scheiman, Mitchell, et al. Clinical Management of Binocular Vision: Heterophoric, Accommodative, and Eye Movement Disorders. Lippincott Williams & Wilkins. 2014;42-43.

13. Maples. NSUCO Oculomotor Test. Available:www.oepf.org/sites/default/files/journals/jbo-volume-3-issue-6/3-6%20Maples.pdf.

14. "NSUCO Oculomotor Test Manual." NSUCO Oculomotor Test Manual | OEP Foundation. Available:www.oepf.org/product/nsuco-oculomotor-test-manual.

15. Portnoy A, Gilaie- Dotan S. "Oculomotor-related measures but not distance visual acuity are predictive of reading ability in first graders"; 2020. Available:biorxiv.orghttps://doi.org/10.1101/2020.03.09.983197