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Influence of Vision on Educational Performance: A Multivariate Analysis

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Abstract: (1) Background: According to the World Report on Vision published by WHO, 123.7 million people around the world have vision impairment due to uncorrected refractive errors. Vision impairment affects many aspects of our lives, and it is related to low academic performance; (2) Methods: A prospective and multicenter study has been carried out in 1400 optical centers in Spain. A visual screening was carried out by optometrists on children aged between 6 and 12; (3) Results: 6673 children of primary school have been checked. The multivariate analysis reveals that 5.2% of the poor academic performance is related to vision. Poor academic performance was independent and significantly affected by sex, age, near vision, hyperopia, binocular dysfunctions, and bad ocular motility; (4) Conclusions: Vision plays a key role in optimum academic performance; consequently, the early detection of refractive errors and other visual problems is essential to improve the academic performance of schoolchildren.

Keywords: academic performance; vision; children; primary school

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1. Introduction

The global education monitoring report (GEM) published by UNESCO, analyzed the fourth sustainable development goal (SDGs) that pretends to ensure inclusive and equita-ble quality education and promote lifelong learning opportunities for all in 2030 [1].

That report highlights that blaming teachers for the inefficacy of educational systems could become more inequalities and learning decreases. To guarantee the educational quality, academic performance should be considered. Academic performance covers a wide relationship among health, visual problems, nutrition, stress, and obesity [2].

To de World Report on Vision published in 2019 by the World Health Organization (WHO), 123.7 million people around the world have vision impairment due to uncorrect-ed refractive errors [3]. Vision impairment affects many aspects of our lives, as far as it has a direct impact on our everyday activities.

In children, vision is especially relevant, and vision impairment is related to a low academic performance [4–6]. Nowadays, the visual demand on children in the classroom has increased. Children are performing a lot of different visual tasks during their days at school, such as reading, writing or using tablets and computers. In 2016, Australian children of primary school spent 47% of the time at school in near tasks, 29% in distance tasks, 15% in distance-to-near and just 9% were computer-based tasks [7]. Thus, if a child's vision does not work properly, that child will not have good participation in the classroom. Binocular problems, such as strabismus or amblyopia, have been related to reading problems in several studies [8–10], so children with reading difficulties should be checked by an eye care professional. The Spanish Council of Optometrists recommends that teachers and parents pay attention to symptoms, such as if the child usually has distractions while reading, has low reading comprehension, has bad handwriting, complains about blurred vision, closes his/her eyes, turns his/her head when doing the homework, etc.

In Spain, pediatric screenings in healthy children include vision screenings at ages that vary depending on the Autonomous Community. According to the recommendations made by the associations PrevInfad and PAPPS infant and adolescence, a complete visual check should be done in children between 2 and 4 years old [11]. However, as pediatric consultants and vision care professionals are over capacity, making those checks in all children is not possible. Nowadays, countries like the USA use questionnaires that serve as screening in children. In that way, a previous screening could be done even at school and vision care professionals can take care of children with vision problems. [12].

However, academic performance is conditioned by many other factors such as motivation, diet habits, the practice of physical activity, sleep habits, etc. [13–16].

Education is a key factor in life opportunities, and equity in education is very relevant as far as it is a major contributor to social development. So, countries with better academic results have less unemployment, and people with the lowest educational qualifications have lower earnings [17].

There are some studies about the influence of vision impairment on academic performance, but it would be interesting to know the impact that vision has on the academic results in order to plan strategies to improve children's educational results.

This study aims to evaluate the influence of vision on the academic performance of primary school children to know if it stops some children from achieving the minimum proficiency level in reading the SGDs promote.

2. Materials and Methods

An observational, prospective, cross-sectional, multicenter and prevalence study was carried out in 1400 optical centers in Spain. A visual screening was carried out by optometrist on children aged between 6 and 12. The data were collected in optical centers that collaborated in the "State of children's vision in Spain 2019" campaign organized by "Vision y Vida" Foundation, using the convenience sampling method. All the optometrists were provided with a username and password to access the website www.verparaaprender.es where they could upload the data collected.

The screening included the following tests:

- Monocular Visual Acuity (distanced vision),
- Fogging test with +2.00 D to exclude hyperopia of $\geq$+2.00 D [18],
- Shober phoria test to evaluate binocular vision,
- Binocular Visual Acuity (near vision),
- Near Point of Convergence (NPC),
- Ocular motility.

Parents were asked about the academic performance of the children, considering it to be a poor academic performance when the student had failed one subject or more at the end of the previous year.

Multivariate analysis for factors associated with academic performance was made, including the poor academic performance as the dependent variable, age as independent variable, Visual Acuity (VA) and Near point of convergence (NPC) as continuous variables, and sex, fogging test, Shober test, and ocular motility as categorical variables. The analyses were performed using Stata IC v.14 (StataCorp).

Parents of all participants declared a clear understanding of the study objectives by signing the informed consent form. The research described herein adhered to the tenets of the Declaration of Helsinki and was approved by the ethics investigation committee of the Universidad Europea de Madrid (CEI-UE) under the code CIPI/19/102.

3. Results

10,216 children between 6 and 12 years old were checked, but just 6673 had data in all variables to do the multivariate analysis.

The model was able to explain 5.2% of the poor academic performance. Table 1 shows the results of each variable in the multivariate analysis and Figure 1 represents graphically these results:

Table 1. Multivariate analysis of poor academic performance with different demographic and visual variables.

Poor Academic Performance	Odds Ratio	Std. Err.	z	$p > z$	[95% Conf. Interval]	
Female	0.704	0.062	−3.980	<0.001	0.593	0.837
Age	1.133	0.025	5.770	<0.001	1.086	1.182
Monocular VA (Right Eye)	0.554	0.223	−1.470	0.142	0.251	1.220
Monocular VA (Left Eye)	0.512	0.210	−1.630	0.102	0.229	1.143
Binocular VA (near vision)	0.374	0.157	−2.350	0.019	0.164	0.851
NPC	1.011	0.007	1.500	0.133	0.997	1.026
Fogging test with +2.00 D	1.394	0.138	3.360	0.001	1.148	1.692
Shober phoria test	1.900	0.247	4.940	<0.001	1.473	2.452
Dificulty in ocular motility	1.817	0.215	5.040	<0.001	1.440	2.292

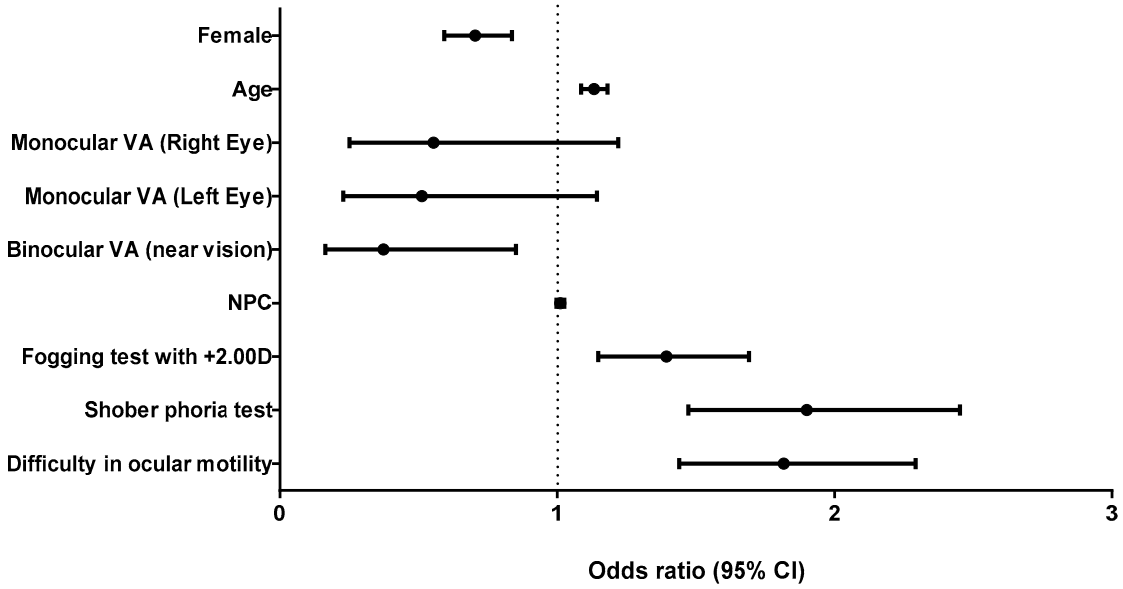


Figure 1. Risk factors for poor academic performance according to the multivariate logistic regression analysis.

Poor academic performance was independent and significantly affected by sex, age, near vision, hyperopia, binocular dysfunctions, and bad ocular motility.

Regarding demographical data, females had a 30% lesser probability than males of having a poor academic performance. Also, from 6 to 12 years old, the probability of having a bad academic performance increased 13% per year.

Concerning VA and refractive errors, each increase of a line of VA in near vision implied a decrease of 60% in the probability of having a poor academic performance, while failing in the fogging test with +2.00 increased this probability by 40%.

Finally, binocular vision also affected academic performance, as children who failed in the Schober test had a 90% greater probability of having a bad performance, and those with ocular motility difficulties 81.7%.

4. Discussion

Academic sustainability refers to the promotion of the academic achievement of students by improving their learning abilities [19]. Martinez-Perez et al. analyzed 16,157 publications in their research published as "Current State and Future Trends: A Citation Network Analysis of the Academic Performance Field". They concluded that academic

performance was related to 9 big areas of research: health, psychology, demography, physical activity, sleep habits, vision, economy, and delinquency [6].

Besides, target 4.1 of the fourth SDGs is the following: "by 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes". The key indicators for this target are the proportion of children and young people: (a) in grades 2/3; (b) at the end of primary; and (c) at the end of lower secondary achieving at least a minimum proficiency level in (i) reading and (ii) mathematics, by sex. [20]. As far as vision plays a very important role in reading competencies, it is essential to assure a good vision as a tool to all children in order they can achieve a minimum proficiency level in mathematics and reading as the SGDs pro-mote.

The link between vision and academic performance has been a subject of discussion for a long time. Special emphasis has been placed on the visual factors associated with learning difficulties, for instance, reduced visual acuity, uncorrected refractive errors, binocular vision dysfunction, and delays in developing the ability to process visual information [17,21,22]. However, the majority of the studies showed fundamental differences regarding study design, target population, and method used for the assessment of academic performance [23], thus producing inconsistent results. This study offers a more consistent assessment of the influence of vision on academic performance, which was accomplished by using a larger sample size than in previous research carried out on the subject [24–26].

According to WHO, refractive errors are the main cause of vision impairment all over the world, myopia being one of the main public health problems [3]. In a recent study in Spain about lifestyles and vision of children between 5 and 7 years old, greater time spent on near activities and using digital devices was associated with higher rates of myopia [26]. This increase in time spent on near activities makes important the early detection of visual problems that could be translated into a bad academic performance.

However, the role that visual acuity and refractive errors play in the academic performance of schoolchildren is a controversial issue, given the variability in study quality and findings of the research available on the topic. According to our results, the studies by Goldstan et al. [27] and Hopkins et al. [28] found that vision deficits in schoolchildren could result in academic failure and concluded that optometric management could have a significant effect on children's academic performance. Conversely, other studies, such as the research by Dirani et al. [29], have not found the link between vision and academic achievement. This may be because the majority of the studies associating vision with academic performance in children have used a case-control study design or correlation analysis. In this way, case-control studies show a greater prevalence of visual dysfunction in the group of low academic achievement, which may indicate that the target visual factor influences academic performance. On the other hand, the quantitative measurements of visual function in correlation studies are associated with the measurement of reading performance and academic capabilities; therefore, strong r values could be misinterpreted as indicating that there is a causal relationship between the two target factors. Both study designs may show a link between vision and academic performance, but it is not possible to establish a relationship of a causal nature [30–33].

Our study demonstrated that good visual acuity, in both distance and near vision, reduces the likelihood of academic failure. These findings are consistent with those of Johnson et al. [34] and Snowdon et al. [35], whose studies showed that children with reduced near vision were more likely to present a reduced reading capability. Similar findings were obtained in the study by Kotingo et al. [18], in which 57.58% of the students with visual disabilities presented scores below 50%, and therefore their academic performance was poorer than in the case of students with normal vision. In another study by Toledo et al. [5], 89.5% of the students with normal visual acuity obtained scores above 50% while in the case of students with poor visual acuity, only 75% obtained scores above that threshold.

On the other hand, good binocular vision is important in achieving adequate academic development. Our study found a link between academic performance and children's phoric state. In this sense, Arasheed et al. [36] concluded that convergence insufficiency

and a weak positive fusional reserve are associated with academic failure. Concurrently, Scheiman et al. [37] reported that a significant improvement in reading capabilities was observed after treating convergence insufficiency. Therefore, near vision activities such as reading or writing require good positive fusional reserve, as when this is reduced, children present difficulty in focusing for long periods. Moreover, children with a low fusional reserve can become symptomatic when carrying out tasks in near vision, with uncontrolled heterophoria giving way to heterotropia [37].

Our study also showed that ocular motility is essential for adequate accommodative performance. In line with these findings, the study by Wood et al. [38] demonstrated that ocular motility is closely related to the speed of visual processing and reading capability.

Regarding gender, we found that the academic performance of male students was likely to be worse than that of female students. Similarly, Cordero Ferrera et al. [39] concluded that girls were more likely to obtain better grades than boys. This is because girls have a greater sense of responsibility when pursuing their goals, while boys tend to rely more on their innate abilities. That is why it is necessary to implement policies in schools aimed at improving academic performance, in order not to condition children's professional pathways.

One of the limitations of this study is that it has not included other important socio-demographical factors such as the economic situation of the family or the educational level of the parents. So, it would be interesting to ask for this information in future studies. The other is the measurement of academic performance by asking parents instead of considering the children's qualifications.

However, our study confirms once again the importance of vision for children by providing a large sample examined by optometrists. How families realized that their children needed glasses is also worth mentioning; in most cases, children noticed themselves that their vision was not right. Diagnosis by a specialist doctor, and warnings from the school were the second and third most reported options, respectively.

5. Conclusions

In conclusion, vision plays a key role in optimum academic performance; consequently, the early detection of visual alterations in schools and primary care centers is vital to improving the academic performance of schoolchildren. However, to achieve this goal, it is necessary to obtain further scientific evidence on how visual characteristics in-fluence academic performance, as well as on visual demands and the effect that refractive correction has on development within the setting of the primary school classroom.

The implementation of vision screening in children could help to improve their vision skills and make them reach a minimum proficiency level in mathematics and reading, as the target 4.1 from the 4th SGDs promotes.

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