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Visual acuity screening, photoscreening and dispensing of glasses with ready to Clip™ technology

Rastreamento visual, photoscreening e dispensação de óculos com a tecnologia ready to Clip™

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Abstract

Background: *The visual screening performed in schools is sometimes the only opportunity to detect uncorrected refraction errors (URE) causing low visual impairments, prejudice in the acquisition of knowledge, dropout and school repetition, poor motor skills, difficulty in social interaction and low self-esteem in schoolchildren.* ***Objectives:*** *To compare the detection of URE in elementary school children by visual screening (measurement of the AV with the Snellen table) and photoscreening; to evaluate the accuracy of the SpotTM Vision Screener (Welch Allyn) as an autorefractor by comparing its refraction measurements with those of the autorefractor Topcon KR 800 (Japan) and to verify the proportion of glasses with ready to ClipTM technology dispensed at the time of the students' evaluation.* ***Methods:*** *Two hundred ninety-seven students were submitted to visual screening (cutoff point: AV monocular ≤ 0.7 and/or difference two Snellen lines between the eyes), photoscreening (cutoff point: hypermetropia ≥ 3, 00D, myopia ≥ 0, 75D and astigmatism > 1D) and the measurement of the refraction error under cycloplegia with the photoscreener and autorefractor. Only the refraction data of the right eye were analyzed. The findings were converted into vectors of magnitude for analysis.* ***Results:*** *The sensitivity and specificity values of the visual screening method were 67.2% and 63.5% and photo screening were 76.1% and 79.1%. The mean difference between refraction by SVS and autorefractor was of + 0.154 SD combined with -0.170 DC in the 6-degree axis for the right eye of each patient.* ***Conclusions:*** *In the population evaluated the method of refractive screening by photoscreener was more effective than the visual screening. The comparison of the results of refraction under cycloplegia with the autorefractor validated the use of photoscreener as an accurate refraction method for the measurement of refractive errors in schoolchildren. The majority of the students received their glasses with ready to Clip™ technology at the time of prescription.*

Keywords: *Visual acuity/diagnosis; Ophthalmologic diagnostic techniques; Ocular refraction; Vision disorders; School health*

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Resumo

Introdução: Os rastreamentos visuais realizados nas escolas são, às vezes, a única oportunidade de deteção dos erros de refração não corrigidos (ERN) causadores de baixa visual, prejuízo na aquisição do conhecimento, evasão e repetência escolar, habilidades motoras pobres, dificuldade na interação social e baixa autoestima nos escolares. **Objetivos:** Comparar a detecção de ERN em escolares do ensino fundamental por meio de rastreamento visual (medida da AV com a tabela de Snellen) e por photoscreener; avaliar a acurácia do SpotTM Vision Screener (Welch Allyn) como autorefrator comparando suas medidas de refração com as do autorrefrator Topcon KR 8000 (Japão) e levantar a proporção de óculos com a tecnologia ready to Clip™ que foram dispensados no momento da avaliação dos escolares. **Métodos:** Duzentos e noventa e sete escolares foram submetidos à rastreamento visual (ponto de corte: AV monocular ≤ 0,7 e/ou diferença duas linhas de Snellen entre os olhos), photoscreening (ponto de corte: hipermetropia ≥3,00D, miopia ≥0,75D e astigmatismo > 1D) e à mensuração do erro de refração sob cicloplegia com o photoscreener e o autorrefrator. Somente os dados de refração do olho direito foram analisados. Os achados foram convertidos em vetores de magnitude para análise. **Resultados:** Os valores de sensibilidade e especificidade do método de rastreamento visual foram 67,2% e 63,5% e do photoscreening, foram 76,1% e 79,1%. A diferença da refração do SVS com o autorrefrator foi de +0,154 DE com -0,170 DC no eixo de 6 graus para o olho direito de cada paciente. **Conclusões:** Na população avaliada o método de rastreamento refrativo por photoscreener foi mais efetivo que o do rastreamento visual. A comparação dos resultados da refração sob cicloplegia com o autorrefrator validou o uso do photoscreener como um método de refração acurado para a mensuração de erros refrativos em escolares. A maioria dos escolares receberam os óculos com a tecnologia ready to Clip™ no momento da prescrição.

Descritores: Acuidade visual/diagnóstico; Técnicas de diagnóstico oftalmológico; Refração ocular; Transtornos da visão; Saúde escolar

Introduction

Eye health is part of the public health context. According to data from the 2000 Census performed by the Brazilian Institute of Geography and Statistics (IBGE - Instituto Brasileiro de Geografia e Estatistica), visual issues are the first cause of disability in 48.1% of 24.5 million Brazilian disabled individuals. [1] Uncorrected refractive error (URE) is the main cause of low vision in elementary school students.[2]

Several experiences and valuable information collected from "Olho no Olho" (Eye-to-eye) campaign, which was carried out by the Brazilian Council of Ophthalmology (CBO - Conselho Brasileiro de Oftalmologia), have significantly substantiated the organization of programs focused on providing large-scale eye care to schoolchildren, as described below.[3] Socioeconomic and cultural conditions hinder the access of students who were identified in visual screenings carried out at schools to eye examinations at accredited Ophthalmology Services. Schoolchildren called-up for full eye examination often present high non-attendance rate (53.7%), which is also high in second appointments (54.3%), a fact that emphasizes the need of conducting eye examination at the school environment.[4] The alleged reasons for such an absenteeism comprise lack of transportation (41.6%) and financial limitations to pay for the transportation of parents and other children, besides that of the student to be examined. Except for "lack of guidance", which was mentioned by 31% of respondents, the other allegations enabled assuming that socioeconomic obstacles are behind students' non-attendance to ophthalmological consultations.[4] Teachers were the ones who mostly noticed students' visual difficulty (70.6% of cases), they were followed by studets' parents (18.9%) and by students themselves (7.9%).[4] It is important helping parents to understand the purpose of having health programs at school, since they are responsible for assuring children's health. Comprehensive home-school-community action is necessary to achieve the common goal of school-age child health. In other words, optical correction projects focused on public school students must be preceded by guidance and persuasion.[4]

Eyeglasses are considered one of the most cost-effective interventions and the easiest way to correct refractive errors. They must have good quality, as well as be affordable and comfortable to enable treatment adherence.[3] The World Health Organization (WHO) has warned about individuals' dificulties to purchase eyeglasses and encouraged member states to prioritize projects focused on distributing eyeglasses for free or at low cost.[5] The Brazilian government should implement the free distribution of eyeglasses with correction lenses, as other countries already did. [6]

Nowadays, the main contradiction in the eye healthcare field lies on the fact that, despite the great technological advancement capable of improving the control and diagnosis of different retinal diseases, little attention is given to assuring students' access to diagnosis and correction of UREs capable of causing visual impairment, impaired knowledge acquisition, school dropout and failure, poor motor skills, social interaction issues and low self-esteem.[3,4] CBO has emphasized the need of taking new actions to control the growing demand for, and expand students' access to, ophthalmological services.[3] One of the ways to expand ophthalmologic care to students lies on incorporating new technologies, such as photoscreener-based refractive screening, to this process.[7-9]

The aims of the current study are i) to compare URE identification in public elementary school students based on visual screening (VA measured through Snellen chart) to that based on photoscreener, ii) to validate the SpotTM Vision Screener (Welch Allyn) as autorefractor by comparing its refractive measurements to those of the Topcon KR 8000 self-refractor (Japan), and iii) to investigate the percentage of ready-to-Clip™ technology-based eyeglasses prescribed at the time schoolchildren are subjected to ophthalmological evaluation.

Methods

After the study protocol was approved by the Research Analysis Ethics Committee of Federal University of Rio Grande do Norte, teachers from Natal City public elementary schools neighboring Farol da Mãe Luiza community were trained by an ophthalmologist to apply the visual acuity test (VAT) to their students and to record the results in a clinical form prepared by the researcher (MRF). Two hundred and ninety-seven (297) students from these schools were referred to full eye examination in the community's multisport gym at Dinarte Mariz School, which was one of the schools involved in the study. Informed Consent Form was signed by the parents or legal guardians of all participants.

The ophthalmological examination comprised the following sequence: i) uncorrected VA measurement based on Snellen chart, ii) three dynamic eye refraction measurements based on SpotTM Vision Screener - Welch Allyn (SVS), iii) cycloplegia based on the instillation of 1 drop of 1% cyclopentolate, supplemented with 1 drop of 1% tropicamide, iv) three ocular refraction measurements under cycloplegia based on SVS and on Topcon KR 8000 autorefractor - Japan (ATR), v) Greens' manual refractor-based subjective refractometry in students selected to receive optical correction, vi) slit-lamp biomicroscopy and vii) fundscopy. Students presenting prescription to correct spherical refractive errors (myopia or hyperopia), with or without astigmatism ≤ ± 1.00D, received eyeglasses based on ready-to-Clip ™ technology at ophthalmological evaluation time. Students with refractive errors and astigmatism > ± 1.00D had their recipes sent to accredited optical laboratory in order to have their eyeglasses assembled.

Statistical analysis

Demographic data and test results were recorded in individual forms and tabulated in database created in Microsoft Excel® spreadsheets.

Screening methods were evaluated by comparing calculated data such as sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), false negative and false positive.

Data about individuals' right eye were collected before refractive error analysis to avoid bias associated with interdependence in eye observations in the same individual. Spherical and cylindrical components were converted into force vector formats in order to make statistical analysis possible. The conversion process was based on the equation by Naeser et al. [10]: MV 900 = m ($sen^2\alpha$-$cos^2\alpha$), wherein MV 900 is the magnitude of the vector on the 900 axis, m is the cylindrical component value expressed in diopters and α is the meridian of the cylindrical component expressed in degrees. The equation refers to the vertical and horizontal refraction components. Equation MV 1350 = m (sen^2 (α - 450) -cos^2 (α - 450) enables calculating the diopter difference between refraction components projected on the 900 and 1350 axes. R-Project software was used for statistical analysis.[11] The univariate analysis used to compare differences between columns of pairs of exams was performed through two-tailed paired Student's t test. Bivariate and trivial analyses were performed through Hotellings' test. Spherical equivalent (SE) difference was calculated by subtracting the SE value obtained through ATR from the SE measured through SVS. The same procedure was applied to MV 900 and MV 1350, respectively. Positive difference has indicated that SVS has overestimated the corresponding value. Trivariate analysis has used 3D graph to assess the association among parameters such as SE, MV 900 and MV 1350, as well as their influence on cycloplegic right eye-refraction differences calculated based on SVS and ATR. Statistical significance level was set at 5% ($p < 0.05$).

Results

The research population comprised 297 students - 122 (41.1%) boys and 175 (58.9%) girls, whose mean age was 9.4 years.

Table 1 shows the students' distribution into two groups, based on the cutoff point adopted for visual screening based on VAT. Students' uncorrected VA values were recorded by teachers in their respective schools.

Table 1

Elementary school students' distribution based on the cutoff point adopted for visual screening conducted with Snellen VA chart (VAT)

Cutoff point of VAT-based visual screening	N	%
VA < 0.7 and/or difference in AV ≥ 2 lines between eyes	129	43,4
VA > 0.7 and/or difference in VA ≤1 line between eyes	168	56,6
Total	297	100,0

Table 2

Shows students' distribution based on the cutoff point adopted for dynamic refractive screening conducted with SVS.

Cutoff point of refractive screening conducted with SVS*	N	%
Hyperopia ≥ +3.00 R, myopia ≥ 0.75 R and/or astigmatism > ±1.00R	99	33,3
Hyperopia < +3.00 R, myopia < 0.75 R and/or astigmatism ≤±1.00R	198	66,7
Total	297	100,0

* SVS: Spot™ Vision Screener – Welch Allyn

Table 2 shows students' distribution based on the cutoff point adopted for dynamic refractive screening conducted with SVS.

Tables 3 and 4 show the number of eyeglasses prescribed based on visual screening (VAT) and on dynamic refractive screening (SVS).

Refractive screening (SVS) without cycloplegia based on the adopted cutoff point has shown sensitivity of 76.1% (51/67), specificity of 79.1% (182/230), PPV of 51.5% (51/99), NPV of 91.9% (182/198), false negative of 5.4% (16/297) and false positive of 16.2% (48/297).

Vectorial and diopter differences between refraction values recorded under cycloplegia, based on SVS and ATR, are shown in Tables 5 and 6.

Bivariate analysis was performed to assess astigmatism influence on differences between refractive values recorded under cycloplegia, based on SVS and ATR (Figure 1).

Trivariate analysis has used 3D graph showing differences between refraction values recorded for the right eye, under cycloplegia, based on SVS and ATR, and expressed by SE, MV 900 and MV 1350 (Figure 2).

Refraction conversion from vector values to the conventional form has shown that the refraction difference, under cyclopegia, between SVS and ATR was + 0.154 SfD and -0.170 CD, on the 6-degree axis of the right eye of each patient, on average.

Forty-nine (73.1%) students with spherical refractive errors (myopia or hyperopia), with or without astigmatism ≤ ± 1.00R, received eyeglasses based on ready-to-Clip™ technology at ophthalmological evaluation time. The remaining 18 (26.9%) students with astigmatism > ± 1.00R had their prescription sent to accredited optical laboratory in order to have their eyeglasses assembled.

Table 3
Number of eyeglasses prescribed based on visual screening (VAT)

Visual screening (VAT)	Eyeglasses prescription		Total
	Yes	No	
AV < 0.7 and/or difference in AV ≥ 2 lines between eyes	45	84	129
AV > 0.7 and/or difference in AV ≤1 line between eyes	22	146	168
Total	67	230	297

Table 4
Number of eyeglasses prescribed based on dynamic refractive screening (SVS)

Visual screening (VAT)	Eyeglasses prescription		Total
	Yes	No	
Hyperopia ≥ +3.00 R, myopia ≥ 0.75 R and/or astigmatism > ±1.00R	51	48	99
Hyperopia < +3.00 R, myopia < 0.75 R and/or astigmatism ≤±1.00R	16	182	198
Total	67	230	297

Discussion

There is high demand for ophthalmological care in Brazil, but the supply is inadequate. According to data from CBO[12] and from IBGE 2000 Census,[1] 11.8 million Brazilians are visually impaired, which explains the high demand for eye health services. The country has more than 17,000 ophthalmologists; however, less than a third of them are accredited to SUS. [13] Visual screening carried out through joint efforts is one of the strategies used to improve the scenario of difficulty in providing universal access to ophthalmological consultations.[14] So far, visual screening is the first opportunity for public school students to undergo ophthalmological assessment and identify risk factors capable of compromising their eye health.[3] Ophthalmological task forces play an important role in Brazil, where more than 80% of the population depends on public health, mainly in remote regions countrywide.[3]

All 297 students investigated in the present study underwent full eye examination. Based on the visual screening (VAT) performed by teachers in schools, 129 (43.4%) students with uncorrected monocular VA ≤ 0.7, and/or with difference in VA ≥ 2 lines between eyes, were referred to full eye examination (Table 1). Based on dynamic refractive screening (without cycloplegia) conducted with SVS, 99 (33.3%) students with hyperopia ≥ +3.00 R, myopia ≥ 0.75 R and/or astigmatism > ± 1.00R were referred to full eye examination (Table 2).

Effective screening programs must identify high rates of schoolchildren with visual issues (high sensitivity). [15] Sensitivity values recorded for visual screening (67.2%) in the current student were lower than the ones for dynamic refractive screening (76.1%), as shown in Tables 3 and 4. Highly sensitive tests must be used to help identifying students who should be referred to full eye examination. Very sensitive tests are mostly important at the beginning of the diagnostic process (for example, in visual screening, task forces and in evaluations carried out outside the medical environment), when there is a large number of diagnostic possibilities and one wants to reduce the likelihood of not identifying all positive cases.[15]

The present study recorded specificity values of 63.5% (VAT) and 79.1% (SVS, without cycloplegia), as shown in Tables 3 and 4. Specificity accounts for determining the proportion of students who do not need to be referred to full eye examination. PPV values recorded in the current study were 34.9% (VAT) and 51.5% (SVS, without cycloplegia); they expressed the likelihood of students with positive screening to present VA and/or refractive error higher than the adopted cutoff point. NPV values were 86.9% (VAT) and 91.9% (SVS, without cycloplegia); they expressed the likelihood of students with negative screening to not present VA and/or refractive error higher than the cutoff point.

The mean age of the students investigated in the current study was 9.4 years. Preschool years are the best time to diagnose and promote amblyopia treatment, since its non-diagnosis burden can be high.[16] However, visual screening application to preschool students has proved to be low cost-effective due to factors such as difficulty in capturing children, lack of trained professionals to examine them, low prevalence of refractive errors requiring optical correction, as well as difficulties associated with amblyopia identification and adherence to treatment.[17] Photoscreener-based refractive screening is a viable alternative to help identifying children with risk factors for amblyopia. [18-20]

SVS is a portable, lightweight, fast and simple-to-use device. [8,9] Data collected in the present study have confirmed that the use of the dynamic refractive screening based on SVS reduced the number of students referred to full eye examination, in comparison to visual screening (VAT).

The present study has shown that differences between mean refraction values recorded under cycloplegia, based on SVS and ATR, and expressed in SE vectors and diopters, were very small and did not present clinical relevance (Tables 5 and 6).

Bivariate analysis (Figure 1) has shown that astigmatism influence on refractive results of SVS and ATR was greater in MV 900. According to Naeser et al. [10], MV 900 is mostly sensitive to eyelid tone and to blinking.

Trivariate analysis has shown that differences between mean refraction values recorded under cycloplegia, based on SVS and ATR, and expressed in SE, MV 900 and MV 1350, were actually very small (Figure 2).

Refraction conversion from vector values to the conventional form has shown that refraction difference under cycloplegia between SVS and ATR was, + 0.154 SfD and -0.170 CD on the

Table 5
Vectorial differences between refractive values recorded under cycloplegia, based on SVS and ATR

	Variables	Mean	SD	P value
Vectorial	SE	+0,07	0,45	<0,05
SVS-ATR	MV 900	+0,10	0,24	<0,05
	MV 1350	+0,02	0,19	>0,05

SVS-ATR: vectorial difference of refraction measured in SpotTM Vision Screener and Topcon KR 8000 autorefractor - Japan, under cycloplegia. SD: standard deviation; SE: spherical equivalent; MV 900: vector magnitude difference projected on axis 900; and MV 1350: vector magnitude difference projected on axis 1350

Table 6
Diopter differences between refractive values recorded under cycloplegia, based on SVS and ATR

	Variables	Mean	SD	P value
SVS-ART	SfD	+0,154	0,44	<0,05
Diopter	CD	-0,170	0,46	<0,05
	Axis	5,896	35,74	>0,05

SVS-ATR: diopter difference of refraction measured under cycloplegia in SpotTM Vision Screener and Topcon KR 8000 autorefractor - Japan; SfD: spherical diopter; CD: cylindrical diopter; SD: standard deviation.

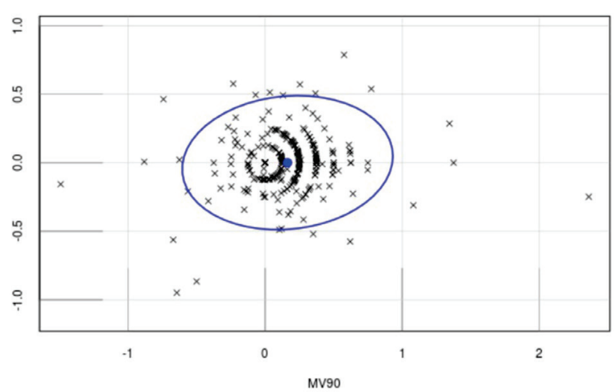

Figure 1: Bivariate analysis of refraction differences recorded based on SVS and ATR, and projected on MV 900 and MV 1350 (right eye).

6-degree axis of the right eye of each patient, on average. These findings have validated SVS as autorefractor presenting accuracy to measure refractive errors in schoolchildren. Similar results were observed by Jesus et al. [8]

SVS uses binocular screening system with infrared LED capable of producing immediate, highly accurate and effective responses. Exams are often performed by placing the device 1 meter away from students and measure spherical refractive errors of ± 7.50R, with steps of 0.25R; cylindrical errors of ± 3.00R, with steps of 0.25R; and cylindrical power axes ranging from 10 to 1800, with steps of 10. It also measures pupil diameters from 4mm to 9mm, with steps of 0.1mm; symmetry of corneal reflexes of 0.5Δ, with steps of 0.1Δ; and pupillary distance from 35mm to 80mm. The equipment has WiFi connectivity to allow transfering and printing results.[21]

Forty-nine (73.1%) students received eyeglasses at prescription time (ready-to-assemble eyeglasses based on ready-to-Clip™ technology). The frames of eyeglasses based on this technology enable fitting pre-cut ophthalmic lenses in them, which favors

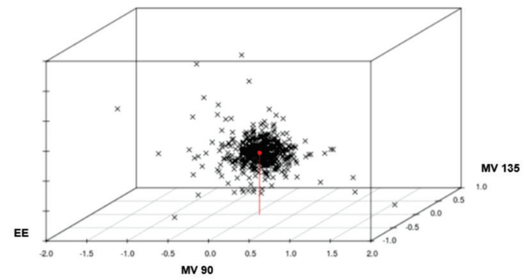

Figure 2: Trivariate analysis showing differences between refraction values recorded for the right eye under cycloplegia, based on SVS (Spot Vision Screen) and ATR (autorefractor), expressed in SE (spherical equivalent), MV 900 (vector magnitude on the 900 axis) and MV 1450 (vector magnitude on the 1450 axis)

their distribution in communities that are difficult to reach. [22] The remaining 18 (26.9%) students with astigmatism > ± 1.00R had their prescriptions sent to accredited optical laboratory in order to have their eyeglasses assembled. An audit conducted by the Federal Audit Court (TCU - Tribunal de Contas da União) in "Olho no Olho" campaign, CBO 2000, has found that 16% of prescribed eyeglasses were no longer delivered to students.[23]

In order to avoid unnecessary referral and high absenteeism, authors of the present study suggest that students belonging to public schools located in remote and/or difficult-to-access areas should be subjected to VAT by their teachers at school, as well as that eye examination should obey the following sequence: i) applying SVS-based dynamic refractive screening to all students); ii) subjecting students diagnosed with hyperopia ≥ +3.00 R, myopia ≥ 0.75 R and/or astigmatism > ± 1.00R, based on VAT and on dynamic refractive screening, to cycloplegia (1 drop of 1% cyclopentolate + 1 drop 1% tropicamide) and to ocular refraction based on SVS; iii) subjecting students who will receive prescription eyeglasses to subjective refraction refinement with the aid of portable handheld refractor (Netropter); iv) biomicroscopy in portable slit lamp; v) fundscopy; and vi) deliverying eyeglasses based on the ready-to-Clip™ technology to students with spherical refractive errors (myopia or hyperopia), with or without astigmatism ≤ ± 1.00R, at ophthalmological assessment time.

All these equipment could be placed in a backpack to enable the displacement of both the ophthalmologist and the equipment from school to school. The frames of eyeglasses based on the ready-to-Clip™ technology and the set of pre-cut lenses could be packed in a suitcase in order to be carried by an optician who, during the exams, would be in charge of assembling and adjusting the eyeglass frames on students' faces.

Conclusions

The photoscreener-based refractive screening method applied to the herein investigated pospulation was more effective than the visual screening method. The comparison of refraction results (under cycloplegia) to those of the autorefractor has validated the use of photoscreener as accurate refraction method to measure refractive errors in schoolchildren. Most students received eyeglasses based on ready-to-Clip™ technology at prescription time.

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