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Comparison of refractometric measurements using 2win® Photoscreener and manual retinoscopy in asymptomatic preschoolers

Comparação das medidas refratométricas através da utilização do Photoscreener 2win® e da retinoscopia manual em pré-escolares assintomáticos

Bruno Viana Gonçalves[1] https://orcid.org/0000-0003-0115-4485
Keila Miriam Monteiro de Carvalho[2] https://orcid.org/0000-0002-7976-8017
Nilza Minguini[3] http://orcid.org/0000-0003-1719-8124
Milton Ruiz Alves[4] https://orcid.org/0000-0001-6759-5289
Fernanda Maria Souto[5] http://orcid.org/0000-0002-2451-9291

Abstract

Objective: *Evaluate the sensitivity, specificity e accuracy of the ocular refraction measured by the 2WIN® photoscreener as a screening method to identify children in need of spectacles prescription according to the criteria published by the Brazilian Society of Pediatric Ophthalmology (BSPO) in asymptomatic children, 6 to 36 months old, and determine the impact of cycloplegia in the sensitivity, specificity and accuracy of this method.* ***Methods:*** *One hundred seventy-eight (178) eyes of asymptomatic children between the ages of 6 and 36 months have been submitted to ocular refraction measurements by the gold-standard method, the manual retinoscopy under cycloplegia, and the method been tested, the 2WIN® photoscreening, both before and under cycloplegia. Results: The 2WIN® photoscreener before cycloplegia was able to identify those patients in need of spectacles prescription according to the criteria published by the BSPO with 100% sensitivity, 93.18% specificity and 93.26% accuracy, when compared to the manual retinoscopy under cycloplegia. The 2WIN® photoscreener under cycloplegia maintained a sensitivity of 100%, but increased specificity to 96.59% and accuracy to 96.63%.* ***Conclusion:*** *The 2WIN® photoscreener before cycloplegia showed high sensitivity, specificity, and accuracy in detection of patients in need of spectacles prescription according to the criteria published by the BSPO in the tested population, with minor increase in specificity and accuracy when the measurements were performed under cycloplegia.*

Keywords: *Refraction, ocular; Retinoscopy; Amblyopia; Screening; Child, preschool*

Resumo

Objetivos: Avaliar a sensibilidade, especificidade e acurácia da refratometria obtida através do aparelho photoscreener 2WIN® como método de rastreio de ametropias com indicação de prescrição de óculos pelos critérios da Sociedade Brasileira de Oftalmopediatria em crianças assintomáticas, de origem extra-hospitalar, de 6 a 36 meses de idade, e determinar se a cicloplegia influencia a capacidade de rastreio do aparelho. **Métodos:** Cento e setenta e oito (178) de crianças com idades entre 6 e 36 meses tiveram sua refratometria mensurada pelo método padrão-ouro, a retinoscopia manual sob cicloplegia, e pelo método em teste, o photoscreener 2WIN®, antes e após a cicloplegia. **Resultados:** O photoscreener 2WIN® é capaz de identificar aqueles pacientes que deveriam receber prescrição de óculos pelos critérios da Sociedade Brasileira de Oftalmopediatria com sensibilidade de 100%, especificidade de 93,18% e acurácia de 93,26%, quando comparado a retinoscopia estática. Sob cicloplegia, o 2WIN® mantém sensibilidade de 100%, porém aumenta sua especificidade para 96,59% e a acurácia para 96,63%. **Conclusão:** O photoscreener 2WIN® se mostrou altamente sensível, específico e acurado para uso como equipamento de triagem daqueles pacientes de 6 a 36 meses que se beneficiariam do uso de óculos pelos critérios da Sociedade Brasileira de Oftalmopediatria, com discreto aumento da especificidade e acurácia quando aplicado em pacientes cicloplegiados.

Descritores: Refração ocular; Retinoscopia; Ambliopia; Rastreamento; Pré-escolar

[1]Ophthalmology Reference Center, Federal University of Goiás, Goiânia, GO, Brazil.
[2]Medical Sciences School, State University of Campinas, Campinas, SP, Brazil.
[3]Clinical Hospital, Medical Sciences School, State University of Campinas, Campinas, SP, Brazil.
[4]Ophthalmology Department, Medical School, University of São Paulo, São Paulo, SP, Brazil.
[5]Post-Graduation Program University of São Paulo, São Paulo, SP, Brazil.

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Introduction

Photoscreeners such as PlusOptix®, 2WIN®, Otago Screener®, Sure-Sight®, Retinomax®, MTI photoscreeners®, iScreen Vision Screener®, among others, do not represent a single type of equipment, but different optical systems that have been launched in the market since the 1990s. Several studies have proven their efficacy as methods to evaluate refractometric errors under cycloplegia in children at pre-school age in comparison to retinoscopy. [1–8]

2WIN® is a photoscreener device capable of objectively and simultaneously evaluating both patients' eyes and providing information such as refractive error measurements, whose cutting point values set for screening, pupillary abnormalities (anisocoria) and eye alignment (overt and strabismus), can be changed in its software. This assessment demands lower collaboration by the child than traditionally adopted methods; moreover, it has been particularly useful to assess children younger than 3 years old. [9]

The aims of the current study were to assess the sensitivity, specificity and accuracy of dynamic refractometry carried out with 2WIN® photoscreener as the method of choice to screen refractive errors of extra-hospital origin, with recommendation of glasses, by using asymptomatic children in the age group 6-36 months, based on criteria set by the Brazilian Ophthalmology Society (SBOP), as well as to determine whether cycloplegia influences the devices' screening ability in this patients.

Methods

Cross-sectional observational study carried out with children (non-hospital population) in the age group 6-36 months who were selected through convenience sampling.

The assessed population comprises children who attend daycare at State University of Campinas and children assisted by task forces at Dr. Manoel Affonso Ferreira Healthcare Center in Campinas City – SP.

Parents and guardians of the selected group were invited to a meeting for project presentation, reading and clarification of doubts regarding the informed consent form and the invitation to participate in the study.

Inclusion criteria encompassed: being in the age group 3-36 months, parents and guardians' participation in the project presentation meeting and their consent for children to participate in the study. In case any of these criteria were not met, the child was excluded from the experiment.

All patients participating in the study were subjected to standard ophthalmologic evaluation: anamnesis, simple and alternating occlusion test, Hirschberg test, slit lamp biomicroscopy, examination with 2WIN® photoscreener (before and after cycloplegia) and static refractive examination in retinoscope of the Luneau type (scale graduation of 0.5D).

Cycloplegia was assessed through two instillations with one drop of 1% cyclopentolate on eye surface, every 5 minutes – examination was carried out 40 minutes after the last drop was administered.

The examination performed with photoscreener was conducted before and after the instillations with the cycloplegic eye drops, in gloom room, at distance of 1 m from the child and measurement repetition until the device would point out that the assessment was reliable (highest quality score). The first highest quality result recorded by the device was the one recorded in participants' measurement spreadsheet.

Retinoscope model 18245 by WelchAllyn® was used at plane mirror position, at work distance of 50cm. Each examination was carried out by a single evaluator, with retesting.

Evaluators composed a team of three ophthalmologists experienced in retinoscopy and trained by the technical team in charge of selling the device in Brazil to screen with the 2WIN® device.

Ophthalmologic morbidities diagnosed during participants' evaluation in the study were properly treated. They were referred to the Ophthalmological Department of the Strabismus Outpatient Center of the Clinical Hospital of the Medical Sciences School of State University of Campinas.

The adopted criteria for glasses prescription were the ones set by SBOP for pre-verbal children: [10]

- Children with myopia (without anisometropia)
  - In the age group between 0-1 year: correct degrees ranging from -4.00D or higher
  - In the age group between 1 and 2 years: correct degrees ranging from -3.00D or higher
  - In the age group between 2 and 3 years: correct degrees ranging from -2.50D or higher
- Children with hyperopia (without anisometropia and orthophoric)
  - In the age group between 0 and 1 years: correct degrees ranging from + 6.00D or higher
  - In the age group between 1 and 3 years: correct degrees ranging from + 5.00D or higher
- Children with hyperopia (with accommodative endotropy of approximately 30 prismatic diopters)
  - In the age group between 0 and 2 years: correct degrees higher than +2.00D
  - In the age group between 2 and 3 years: correct degrees higher than +1.50D
- Children with astigmatism (without anisometropia)
  - In the age group between 0 and 2 years: correct degrees higher than 2.50D
  - In the age group 2 and 3 years: correct degrees higher than 2.00D
- Children with hyperopic anisometropia
  - In the age group between 0 and 1 years: correct degree of + 2.00D or higher
  - In the age group between 1 and 3 years: correct degree of + 1.50D or higher
- Children with myopic anisometropia
  - In the age group between 0 and 3 years: correct degrees of – 2.50D or higher
  - In the age group between 1 and 3 years: correct degrees of – 1.50D or higher

The analysis of variance (ANOVA) was adopted to compare the refractometric measurements from both sides (right and left) at the two photoscreener evaluation times (before and after cyclopegia) and to compare both methods (photoscreener and static manual retinoscopy). The assessed refractometric measurements were turned into posts before ANOVA in case of repeated measurements, since they did not meet the normal distribution. Significance level was set at 5%.

2WIN® photoscreener sensitivity, specificity and accuracy were calculated before and after cycloplegia.

Results

In total, 178 eyes, from 89 children in the age group 6-36 months, were assessed. Mean age of the sample was 21.74 months, standard deviation was 10.48 months and the median was 23 months. With respect to sex, 43 children were boys (48.31%) and 46 were girls (51.69%).

The statistical comparison of refractometric measurements was carried out in 2WIN® photoscreener before and after cycloplegia, and it evidenced statistical interaction between spherical power measurements recorded through pre- and post-cycloplegia photoscreening, and laterality (p=0.1252). The same was observed for cylindrical power measurements of pre- and post-cycloplegia photoscreening (p=0.3437) and for variable spherical equivalent power (p=0.4234).

Regardless of the assessed eye, the spherical and cylindrical values gotten by the photoscreener before and after cycloplegia, as well as the spherical equivalent, were different from each other; power measured before cycloplegia was higher than power measured after it, through this method (p<0.0001).

Median, mean, minimal and maximal values, and the standard deviation of spherical and cylindrical powers measured with photoscreener, as well as values recorded for the spherical equivalent variable are shown in Tables 1-3.

Table 1
Statistical analysis of spherical power measurements gotten through refractometry carried out with 2WIN® photoscreener before and after cycloplegia

Variable	n	measurement (SD*)	Standard deviation (SD*)	Minimal (SD*)	Median (SD*)	Maximal (SD*)
Pre-cycloplegia right eyes	89	1,20	0,97	-2,00	+1,00	+4,00
Pre-cycloplegia left eyes	89	1,08	0,95	-1,00	+1,00	+3,75
Post-cycloplegia right eyes	89	1,85	1,00	-1,75	+2,00	+4,75
Post-cycloplegia left eyes	89	1,81	0,98	-1,25	+1,75	+5,25

ANOVA results for repeated measurements with posts' transformation:
- Comparison between times (before and after cycloplegia): p < 0.0001 (pre < post)
- Comparison between sides (right and left): p = 0.02 (right > left)
- Interaction** between time and side: p = 0.1252
- *SD = Spherical diopters
- **Assess whether the refractometric measurement before and after cycloplegia disregards eye side (p>0.05 is indicative of no interaction, i.e., difference between times disregards the sides).

Table 2
Statistical analysis of cylindrical power measurements recorded through refractometry carried out with 2WIN® photoscreener before and after cycloplegia

Variable	n	Mean (CD*)	Standard deviation (CD*)	Minimal (CD*)	Median (CD*)	Maximal (CD*)
Pre-cycloplegia in the right eye	89	-1,05	0,78	-3,25	-0,75	0
Pre-cycloplegia in the left eye	89	-0,97	0,72	-3,00	-0,75	0
Post-cycloplegia in the right eye	89	-0,80	0,64	-3,25	-0,50	0
Post-cycloplegia in the left eye	89	-0,76	0,62	-3,00	-0,50	0

ANOVA results recorded for repeated measurements with posts' transformation:
- Comparison between times (before and after cycloplegia): p < 0.0001 (pre < post)
- Comparison between sides (right and left): p = 0.3774
- Interaction** between time and side: p = 0.3437
- * Cylindrical diopters

**Assesses whether the refractometric measurement before and after cycloplegia disregards eye side (p > 0.05 is indicative of lack of interaction, i.e., the difference between times disregards the sides)

Table 3
Statistical analysis of spherical equivalent measurements gotten through refractometry carried out with 2WIN® photoscreener before and after cycloplegia

Variable	n	Mean (DE*)	Standard Deviation (SD*)	Minimal (SD*)	Median (SD*)	Maximal (SD*)
Pre-cycloplegia in the right eye	89	+0,68	0,89	-3,00	+0,50	+3,00
Pre-cycloplegia in the left eye	89	+0,59	0,84	-1,63	+0,50	+3,25
Post-cycloplegia in the right eye	89	+1,44	0,95	-2,13	+1,38	+4,13
Post-cycloplegia in the left eye	89	+1,43	0,94	-1,63	+1,25	+4,63

ANOVA results recorded for repeated measurements with posts transformation:
- Comparison between times (before and after cycloplegia): p < 0.0001 (pre < post)
- Comparison between sides (right and left): p = 0.0426 (right > left)
- Interaction** between time and side: p = 0.4234
- * SD = Spherical diopters
- ** Assesses whether the refractometric measurement before and after cycloplegia disregards eye side (p > 0.05 is indicative of lack of interaction, i.e., difference between times disregards the sides).

The statistical comparison of refractometric measurements recorded with 2WIN® photoscreener after cycloplegia to measurements taken through retinoscopy under cycloplegia made it possible observing that, regardless of the assessed eye (right or left), spherical or cylindrical measurements taken with photoscreener after cycloplegia and through static manual retinoscopy, as well as the resulting spherical equivalents, were different from each other and did not present statistical interaction. Values recorded for the three variables through photoscreener were higher than the ones gotten through retinoscopy.

Mean spherical diopter values recorded with post-cycloplegia photoscreener for the right and left eyes were 1.85 ± 1.00SD and 1.81± 0.98SD, respectively; and 1.47 ± 0.86DE and 1.42 ± 0.85SD, through retinoscopy, respectively.

The difference between spherical diopter means recorded with photoscreener and post-cycloplegia retinoscopy for the right

Table 4
Statistical analysis comparing the spherical power measurements after cycloplegia recorded through refractometry carried out with 2WIN® photoscreener and through retinoscopy

Variable	n	Mean (SD*)	Standard deviation (SD*)	Minimal (SD*)	Median (SD*)	Maximal (SD*)
Right eye measured with photoscreener	89	+1,85	1,00	-1,75	+2,00	+4,75
Left eye measured with photoscreener	89	+1,81	0,98	-1,25	+1,75	+5,25
Right eyes measured through schiascopy	89	+1,47	0,86	-1,50	+1,50	+4,00
Left eyes measured through schiascopy	89	+1,42	0,85	-1,50	+1,50	+3,50

ANOVA results recorded for repeated measurements with posts' transformation:
•Comparison between methods (photoscreener and retinoscopy): $p < 0.0001$ (photoscreener > retinoscopy)
•Comparison between sides (right and left): $p = 0.1996$
•Interaction** between method and side: $p = 0.84499$
•*SD = Spherical diopters
•**Assesses whether the refractometric measurement taken with photoscreener and retinoscopy disregards eye side ($p > 0.05$ is indicative of lack of interaction, i.e., difference between methods disregards the sides).

Table 5
Statistical analysis comparing cylindrical power measurements after cycloplegia taken through refractometry carried out with 2WIN® photoscreener or through retinoscopy

Variable	n	Mean (DC*)	Standard deviation (DC*)	Minimal (DC*)	Median (DC*)	Maximal (DC*)
Right eyes measured with photoscreener	89	-0,80	0,64	-3,25	-0,50	0
Left eyes measured with photoscreener	89	-0,76	0,62	-3,00	-0,55	0
Right eye measured through schiascopy	89	-0,58	0,57	-2,50	-0,50	0
Left eye measured through schiascopy	89	-0,57	0,56	-2,50	-0,50	0

ANOVA results recorded for repeated measurements with posts transformation:
• Comparison between methods (photoscreener and retinoscopy): $p < 0.0001$ (photoscreener < retinoscopy)
• Comparison between sides (right and left): $p = 0.5601$
• Interaction** between method and side: $p = 0.5221$
• ** Assesses whether refractometric measurements taken with photoscreener and retinoscopy disregard eye side ($p > 0.05$ is indicative of lack of interaction, i.e., difference between methods disregards sides).

Table 6
Statistical analysis comparing spherical equivalent measurements after cycloplegia taken through refractometry carried out with 2WIN® photoscreener and through retinoscopy

Variable	n	Mean (SD*)	Standard deviation (SD*)	Minimal (SD*)	Median (SD*)	Maximal (SD*)
Right eyes measured with photoscreener	89	1,44	0,95	-2,13	1,38	4,13
Left eyes measured with photoscreener	89	1,43	0,94	-1,63	1,25	4,63
Right eyes measured through schiascopy	89	1,17	0,82	-1,50	1,25	3,75
Left eyes measured through schiascopy	89	1,14	0,79	-1,50	1,25	3,25

ANOVA results recorded for repeated means with posts' transformation:
• Comparison between methods (photoscreener and retinoscopy): p = 0.0010 (photoscreener > retinoscopy)
• Comparison between sides (right and left): p = 0.3272
• Interaction** between method and side: p = 0.5460
• * SD = Spherical diopters
** Assesses whether the refractometric measurements taken with photoscreener and through retinoscopy disregard eye side (p > 0.05 is indicative of lack of interaction, i.e., difference between methods disregards the sides).

and left eyes was 0.38D and 0.39D, respectively.

Median, mean, minimal and maximal values, as well as the standard deviation of spherical and cylindrical powers measured with photoscreener under cycloplegia and through static retinoscopy, as well as values deriving from the spherical equivalent, are shown in Tables 4-6.

By applying criteria set for glasses prescription for pre-verbal children by SBOP, (10) pre-cycloplegia 2WIN® presented 100% sensitivity, 93% specificity and 93.26% accuracy in comparison to manual retinoscopy.

After instillation with cycloplegic eye drops, 2WIN presented 100% sensitivity, 96.59% specificity and 96.63% accuracy.

See Tables 7 and 8 for quantitative details about recommendation for glasses based on different methods.

Table 7
Comparison of recommendation for glasses based on measurements taken with pre-cycloplegia 2WIN® photoscreener to that of static retinoscopy

		Static retinoscopy	
		Recommendation for glasses	No recommendation for glasses
Pre-cycloplegia 2WIN® photoscreener	Recommendation for glasses	1	6
	No recommendation for glasses	0	82

Table 8
Comparison of recommendations for glasses based on measurements taken with post-cycloplegia 2WIN® photoscreener to that of static retinoscopy

		Static Retinoscopy	
		Recommendation for glasses	No recommendation for glasses
Post-cycloplegia 2WIN® photoscreener	Recommendation for glasses	1	3
	No recommendation for glasses	0	85

Discussion

According to Kawamura,[11] sensitivity is the likelihood of an ill and tested individual having its test presenting positive results (changed); specificity is the likelihood of a normal and tested individual having its test with negative results (normal); and accuracy is the ratio expressing how much a test gets right diagnostics, i.e., the total sum of correct results divided by the total of results.

The current study observed that 2WIN® presented high sensitivity, specificity and accuracy for screening children at pre-verbal age with recommendation for glasses based on criteria set by SBOP. Therefore, it is a promising screening tool.

Besides, 2WIN® requires less training than manual retinoscopy for its performance, and this is a strong factor in favor of its use as careening tool.

Results have shown significant statistical divergence between measurements taken through retinoscopy and with 2WIN® photoscreener under cycloplegia. This difference was equal to, or higher than, 0.75SD in almost one third of cases. However, the fact that 2WIN® presented high sensitivity, specificity and accuracy as screening method under the herein applied conditions overcomes its limitations.

It was observed that 2WIN® was not capable of fully neutralizing the effect of accommodation in its dynamic measurement, given the significant statistical difference of measurements taken under both conditions. However, the difference in the static measurement was often small, and it did not affect the ability of the

device to identify patients with refractive error above the cutting points for glasses' prescription set by the Brazilian Ophthalmology Society.[10] Thus, the observed difference did not invalidate its ability to screen at dynamic accommodation mode pre-school children who would benefit from glasses' prescription. It is important highlighting that cycloplegia did not increase the methods' sensitivity, but it increased its specificity by 3.41%.

Most authors who have published articles about this topic found similar results about the inconsistency of refractometric measurements taken with photoscreeners before and after cycloplegia. Ozdemir et al.[12] observed reduced cylindrical power after cycloplegia with PlusOptix®, whereas Yalcın et al.[13] observed cylindrical power consistency, but with reduced spherical power consistency after the administration of cycloplegic eye drops.

Cordonnier et al.[5] recorded similar results by testing photoscreener Retinomax® and concluded that it has good potential as screening tool (it distinguishes patients below and above the cutting points set by the device), but it has limitations regarding refractometry.

Thus, although this device does not replace the manual retinoscopy in the routine of ophthalmologists, 2WIN® photoscreener was accurate enough to be used as tool to screen refractive errors in the population of children in the age group 6-36 months, without known ophthalmological comorbidity, that would benefit from glasses' prescription based on SBOP criteria.

Conclusion

2WIN® photoscreener presented 100% sensitivity, 93.18% specificity and 93.26% accuracy under dynamic accommodation conditions for the detection of pre-verbal individuals in need of glasses, based on criteria set by the Brazilian Ophthalmology Society. The administration of cycloplegic eye drops kept the methods' sensitivity at 100%, but increased its specificity to 96.59% and accuracy to 96.63%.

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Corresponding author:
Bruno Viana Gonçalves
Rua T38, número 777, apartamento 301A, setor Bueno,
Goiânia, Go, Brasil.
CEP: 74223-045.
E-mail: brunovianamed@gmail.com