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ORIGINAL ARTICLE

Treatment of aniseikonia induced by optical correction of anisometropia in elementary school children

Tratamento da aniseiconia induzida na correção óptica de anisometropia em escolares do ensino fundamental

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ABSTRACT

Objectives: *To compare the aniseikonia and the stereopsis in school children anisometropes of the first-year of elementary school corrected with stock ophthalmic lenses with base curve selected to minimize the interocular size difference of retinal images and with size lenses suggested by the software Aniseikonia Inspector 3, and to check the preference of them for one of these forms of correction.* ***Methods:*** *Nineteen school children with anisometropia ≥ 1.5 D in corresponding meridians, in the use of glasses with stock ophthalmic lenses and with size lenses were evaluated for aniseikonia (software Aniseikonia Inspector 3) and stereopsis (Stereo Fly test with LEA symbols). The preference for one of the forms of correction was verified after 40-50 days of wearing glasses.* ***Results:*** *The mean and standard deviations of the vertical and horizontal aniseikonia in the use of glasses with stock ophthalmic lenses and with size lenses were, respectively, -1.05% ± 2.20% and-1.37% ± 2.36% (p = 0,82739) and -0.895% ± 2.23% and -1.16% ± 2.03% (p = 0,77018). 31.6% of the school children corrected with size lenses and 21.1% of the students corrected with stock ophthalmic lenses identified the optotypes that suggest stereopsis less than 100 seconds of arc (p = 0.475). Regarding the preference, 4/15 (26.7%) of the students chose the glasses with size lenses, 2/15 (13.3%) chose the glasses with stock ophthalmic lenses, and for 9/15 (60%) the choice was indifferent.* ***Conclusion:*** *The induced aniseikonia in school children with anisometropia corrected with size lenses suggested by the software Aniseikonia Inspector 3 was similar to that obtained in the correction with stock ophthalmic lenses with base curves selected to minimize the difference of interocular size of retinal images.*

Keywords: *Anisometropia; Aniseikonia; Stereopsis; Eye health; Vision disorders; School health; Child.*

RESUMO

Objetivos: Comparar a aniseiconia e a estereopsia em escolares anisometropes do primeiro ano do ensino fundamental corrigidos com lentes oftálmicas de estoque com curvas-base selecionadas para minimizar a diferença de tamanho interocular das imagens retínicas e com lentes iseicônicas sugeridas pelo software Aniseikonia Inspector 3 e verificar a preferência dos escolares por uma destas formas de correção. **Métodos:** Dezenove escolares com anisometropia ≥ 1,5 D em meridianos correspondentes no uso de óculos com lentes oftálmicas de estoque e com lentes iseicônicas foram avaliados para aniseiconia (software Aniseikonia Inspector 3) e estereopsia (teste Stereo Fly test com símbolos LEA. A preferência por uma das formas de correção foi verificada após 40-50 dias de uso dos óculos. **Resultados:** As médias e os desvios-padrão das aniseiconias vertical e horizontal no uso de óculos com lentes oftálmicas de estoque e com lentes iseicônicas foram, respectivamente, -1,05% ± 2,20% e -1,37% ± 2,36% (p=0,82739) e -0,895% ± 2,23% e -1,16% ± 2,03% (p=0,77018). 31,6% dos escolares corrigidos com lentes iseicônicas e 21,1% dos escolares corrigidos com lentes oftálmicas de estoque identificaram os optotipos que sugerem estereopsia < 100 segundos de arco (p= 0,475). Em relação à preferência, 4/15 (26,7%) escolheram os óculos com lentes iseicônicas, 2/15 (13,3%) escolheram os óculos com lentes oftálmicas de estoque e para 9/15 (60%) a escolha foi indiferente. **Conclusão:** A aniseiconia induzida nos escolares anisometropes corrigidos com lentes iseicônicas sugeridas pelo software Aniseikonia Inspector 3 foi similar ao obtido na correção com lentes oftálmicas de estoque com curvas-base selecionadas para minimizar a diferença de tamanho interocular das imagens retínicas.

Descritores: Anisometropia; Aniseiconia; Estereopsia; Saúde ocular; Transtornos da visão; Saúde escolar; Criança.

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Introduction

Anisometropia is the name given to the condition in which the refractive error is different between the eyes. [1,2] It may result from interocular differences in the refractive power (refractive anisometropia), or axial length (axial anisometropia).[1,2] In population studies, the prevalence of anisometropia ranges from 1-20% depending on the criteria adopted, age, and characteristics of the sample distribution.[3-6] In children aged 6-8 years, the prevalence of anisometropia in spherical equivalent (EE) ≥1D was estimated at 8.5%; and in children aged 12-13 years in 9.4%.[7-9] Anisometropia is one of the main causes of amblyopia and strabismus in children.[10-11]

In the optical correction of the anisometropias the refractive disparity is changed by power disparity generating the aniseiconia that is defined by the difference in size or shape of the cortical representations of the images coming from both eyes. (1) Although most eyeglass wearers have a mild aniseiconia (<1%), values ≥2% are considered clinically significante, and may trigger symptoms that may negatively impact the quality of life.[12] The symptoms arising from aniseiconia are highly variable, and are related not only to the type and magnitude of anisometropia, but also to the optical correction used and the user's ability to adapt to this correction.[12]

When the optical correction of anisometropia has the intention of treating aniseiconia, then changes in the frontal curvatures (basal curves), thicknesses, facets and refractive indices of ophthalmic lenses can alter the sizes of the retinal images. [3,13,14] In general, lenses with flatter front curvatures minify the retinal image, and lenses with more curved frontal curvatures magnify it.[3,12] According to this rule, in the optical correction of an anisometrope patient, the choice of stock lens with flatter anterior curvature for the eye forming the larger retinal image and directing the other stock lens with more curved frontal curvatuta to the eye forming the smaller retinal image can reduce aniseiconia by 2-3 %.[14]

The software Aniseikonia Inspector 3 (Optical Diagnostics) measures aniseiconia, and suggests modifications in the frontal curvatures, thicknesses, facets, and vertex distance of ophthalmic lenses, that is, it proposes the making of iseiconic lenses for its treatment. [15,16] On the other hand, the choice of stock lenses with frontal curvatures (base curves) selected to minimize the difference in the interocular size of the retinal images since the base curve is the most important modifiable factor of lenses in relation to aniseiconia[17] may be the most affordable and least expensive solution.

The objective of the present study was to compare induced aniseiconia in the optical correction of anisometropia to the choice of stock ophthalmic lenses with appropriate base curves and to the iseiconic lenses suggested by the software Aniseikonia Inspector in first grade students. And as specific objectives are to compare the stereopsis and check the preference of anisometrope students by one of these two forms of optical correction.

Methods

A prospective analytical observational study was carried out at the ambulatory of Clínica Oftalmológica do Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo (HCFMUSP) between May 2017 and June 2018. The study was approved by the Ethics Committee for Research Project Analysis of HCFMUSP. Signature of the free and informed consent term was obtained from the parents or legal representative of the participants.

The study population consisted of 19 schollers from the first grade of elementary school enrolled in public schools in the city of São Paulo aged between 7 and 9 years. The students previously underwent visual screening by teachers, and were referred to HCFMUSP for ophthalmological evaluation as part of the program Visão do Futuro. Students with anisometropia ≥1.5D were included in the corresponding meridians with corrected visual acuity ≥0.8 in both eyes. Strabic, amblyopic (interocular corrected visual acuity difference of 2 or more lines on the Snellen optometric scale) students with opacity of the ocular optic media, neurological disorders, and/or mental retardation were excluded.

The study was carried out in two stages. In the first stage, a complete ophthalmologic assessment (measurement of visual acuity, extrinsic ocular motility, biomicroscopy and ophthalmoscopy) was carried out, with refraction under cycloplegia (instillation of two drops of cyclopentolate 1% in the lower conjunctival sac every five minutes, about 30 minutes after the instillation of the second drop manual and computed scintigraphy were carried out with the use of the Topcon KR8000 automatic refractometer. The subjective clinical refractometry was performed using the Topcon VT10 manual refractor, Japan. In the end, the best corrected visual acuity was recorded with the values of the prescription of the refractive error. The students then had the aniseiconia measured using the software Aniseikonia Inspector 3. The optical correction of anisometropia was mounted in a test frame with green and red filters to dissociate the images of both eyes. The student was positioned in front of the computer monitor with the software Aniseikonia Inspector 3. The use of the green filter in the right eye was standardized. The test began with the student pointing out on the computer screen which of the two rectangular boxes presented was higher; then they continued to point out which of the rectangular boxes presented was larger. If the images look the same for the schollchild, the examiner would select the "E" button for equal. After completing the evaluation, the software Aniseikonia Inspector suggested iseiconic lenses with modifications in the frontal curvatures, thicknesses, and facets to reduce the aniseiconia induced by the optical correction. The results of the aniseiconia evaluation were obtained in percentage of magnification along with a value of consistency that allowed considering the results reliable or inconsistent. By definition, aniseiconia is expressed as a relative difference in size and shape of the image relative to the right eye. For example, if the aniseiconia measured is -3%, this means that it would be necessary to magnify the image of the right eye by 3% to cancel out the aniseiconia induced by that optical correction. The aniseiconia was measured in the vertical and horizontal meridians in the angular field of 4°, as suggested in the manual of the Aniseikonia Inspector 3.(15)

The prescription for the correction of the refractive errors was sent for the preparation of two glasses: one to be made with the iseiconic lenses suggested by the software Aniseikonia Inspector 3, and the other with stock lenses. Both lenses were CR-39. In the case of stock lenses (semi-finished blocks), the base curves were chosen by searching the values in surfacing tables(18). In the stock lenses, only the posterior surface was surfed. In the iseiconic lenses, both surfaces were surfed. The two glasses were prepared with identical acetate frames. To facilitate the identification, the glasses with iseiconic lenses had a discrete marking on the inner portion of the right frame.

In the second stage of the investigation, aniseiconia, stereopsia and the student preference were evaluated by one of the two forms of correction. The Aniseikonia Inspector 3 test was carried out with the student wearing glasses with the stock lenses, and with the iseiconic lenses interpolating the green filter on the right eye and red one on the left eye to dissociate the images and allow the measurement of aniseiconia. Stereopsia was measured with each of the optical corrections using the Stereo Fly test with the LEA symbols (Stereo Optical Co. Inc., USA). Students who identified the optotypes suggesting the presence of stereopsis <100 seconds of arch were considered with normal stereopsia, with the other students being considered subnormal.

During the delivery of the glasses, the legal gardian was informed that the student should wear each of the glasses for 20 days. The order of choice informed for wearing glasses was previously determined randomly. The legal guardian was informed that they would be contacted after 40-50 days of delivery of the glasses to inform the student's preference for one of the optical corrections received.

Demographic data and test results were recorded on individual records, and a tabulated database was created in Microsoft Excel® spreadsheets. The calculations and statistical analyzes were carried out with the aid of the softwares R (R Core Team, 2018)(19) and Past - version 3.20(20). In order to graphically analyze the variation of the lens parameters (frontal curvature, thickness, and position of the lens facet in the bevel) in relation to the factors treatment (digital surfacing and iseiconic lenses prescribed by the software) and eye (right and left), non-metric multidimensional multivariate analyzes with Euclidean distance (N-MDS - Non-metric Multidimensional Scaling) were carried out.

The confidence intervals (95% CI) were calculated for the analysis of aniseiconia and esteropsia with the use of the digital and iseiconic surfacing lenses (software). The normality of the variables was tested using the Shapiro-Wilk normality test (α = 0.05). In the analyzes of aniseiconia and stereopsis, the variables were compared with the paired Student's t test (α = 0.05).

Results

The study population consisted of 19 students aged between 7 and 9 years, of which 15 (79%) were female.

Table 1 shows the distribution of refractive errors, axial lengths, and interocular differences of axial lengths.

A non-metric multidimensional multivariate analyzes, N-MDS, with Euclidean distance (Table 2 and Figures 1 and 2) was carried out to graphically analyze the parameter variation of the stock and iseiconic lenses.

Figure 1 graphically compares the set of parameters of stock (Optical) and iseiconic (Software) lenses by non-metric multidimensional multivariate analyzes N-MDS, with Euclidean distance (stress = 0.053).

Figure 2 shows that the parameter variation of stock (Optical) and iseiconic (Software) lens in the reduced space of the N-MDS ordering was not influenced by the eye factor (right or left).

Table 3 presents the results of vertical and horizontal aniseiconias measured with the use of stock (Optic) and iseiconic (Software) lenses.

Table 4 and figure 3 show the results of stereopsia evaluations in the use of stock (Optic) and iseiconic (Software) lenses. Stereopsia values <100 seconds of arc were considered normal.

Regarding preference for glasses: 13.3% (2/15) students reported preferring glasses with conventional lenses, 26.7% (4/15) chose glasses with iseiconic lenses, and 60% (9/15) students mentioned no difference in the choice of glasses.

Discussion

To identify the best cost-effective treatment for aniseiconia induced by optical correction of anisometrope students included in the present study we have to answer the following two questions: (1) Can we treat aniseiconia with stock lenses with selected base curves to minimize the difference of interocular size of retinal images? or (2) Should we treat aniseiconia with the iseiconic lenses suggested by the software Aniseikonia Inspector 3?

When the optical correction of anisometropia is intended to treat aniseiconia, manipulation of the parameters (base curve, thickness, vertex distance, and refractive index) can be used to modify the size of the retinal image.[2] Nomograms and complicated calculations are not always necessary, considering that the frontal curvature seems to be the most important modifiable factor.[3] In a study carried out in 2016, Al-Habdan found that by keeping the other parameters alike, lenses with flatter base curves minimized the retinal image, whereas lenses with more curved base curves magnified the retinal image.[21]

In the present study, the results of the N-MDS order showed statistically significant differences between the lens sets of parameters (stress = 0.053, Figure 1) that were not influenced by the eye factor (right or left) (stress = 0.055, Figure 2).

The differences between vertical (p = 0.82739) and horizontal (p = 0.77018) aniseiconia values induced in the optical correction by stock lenses and iseiconic lenses in anisometropic students were not statistically significant (Table 3). These results suggest that the treatment of induced aniseiconia in the optical correction of anisometrope students can be done with selected stock lenses with appropriate frontal curvatures (base curves). The choice of stock lenses resulted in the best cost-benefit due to dispensing iseiconic lenses, which are less accessible and certainly more expensive.

The study verified that the majority of the students in the use of both optical corrections presented subnormal stereopsia, with a slight tendency to better retention of stereopsis in the use of the iseiconic lenses (Table 4 and Figure 3). However, there was no statistically significant difference between the two optical corrections (p=0.475).

Regarding the preference, 2 (13.3%) students chose glasses with stock lenses, 4 (26.7%) preferred glasses with iseiconic lenses, and for 9 (60%) the choice was indifferent.

The limitations of the study were: (1) the small casuistry; (2) the nature of selection of students who included only non-amblyopic and non-strabismic anisometropes and wearers of glasses for at least one year, which undermined the generalization of data; (3) the use of only CR-39 material for the manufacture of the glass lenses, and (4) information about the preference for one of the glasses having been obtained by contacting the legal guardian of the student.

Conclusion

As a conclusion, it was verified in the present study that the optical correction of anisometropic students with stock lenses with base curves selected to minimize the interocular size difference of the retinal images obtained results similar to those found in the use of the iseiconic lenses suggested by the software Aniseikonia Inspector 3.

Table 1
Distribution of refractive errors, axial lengths, and interocular differences of axial lengths.

N	Sfe RE	Cyl RE	Cyl Axis RE	Sfe LE	Cyl LE	Cyl Axis LE	Axl RE	Axl LE	Diff Biom
1	7.00	-4.00	180	4.00	-2.00	180	20.14	20.68	0.54
2	0.25	-1.00	95	-1.50	-1.75	53	22.61	23.22	0.61
3	-1.75	-3.50	180	2.00	-2.25	180	23.98	22.36	1.62
4	-2.25	-2.75	20	-0.25	-2.75	175	24.97	24.04	0.93
5	-5.25	-1.00	160	-1.75	-2.75	180	25.43	24.74	0.69
6	-4.00	-3.50	180	-0.25	-2.50	165	25.23	23.32	1.91
7	-1.50	-2.00	15	0.00	-0.50	165	22.42	22.15	0.27
8	-7.50	-4.00	15	-1.75	-3.25	170	25.27	23.31	1.96
9	-4.25	-1.50	180	-1.75	-0.75	15	26.02	24.83	1.19
10	-6.75	-2.00	90	-1.00	0.50	60	26.41	23.93	2.48
11	0.50	-0.25	130	-2.50	-0,75	150	22.94	24.56	1.62
12	-4.25	-1.75	165	-2.00	-1.50	15	25.25	24.16	1.09
13	-3.00	-1.00	155	-6.00	-0.75	50	23.48	24.16	0.68
14	-5.25	-2.50	165	-1.50	-2.75	15	23.85	23.14	0.71
15	2.00	-2.00	180	4.00	-3.50	180	22.29	22.12	0.17
16	-0.50	-2.75	175	-2.25	-1.50	10	22.58	22.97	0.39
17	-4.00	-2.50	30	1.50	-1.25	170	25.18	22.75	2.43
18	3.25	-1.50	170	5.25	-3.00	180	21.12	20.63	0.49
19	4.75	-4.50	180	2.50	-1.00	105	20.67	20.87	0.20

Refractive errors in diopters; Sfe: spherical component; Cil: cylindrical component and Cyl axis; RE right eye; LE left eye; AxL: Axial length in mm, and Diff: interocular difference of axial length

Table 2
Average values, standard deviations, and 95% CI confidence intervals of the parameters frontal curvature (D1), thickness (t), and facet of conventional and iseiconic lenses

Parameters	Iseiconic Lens Software				Conventional Lens Optic			
	Average	SD	IC 95%		Average	SD	IC 95%	
D1	5.93	2.17	5.23	6.60	3.29	1.86	2.69	3.87
T	2.87	1.50	2.35	3.28	2.42	0.75	2.16	2.64
Facet	39.26	8.31	36.58	41.95	29.47	2.26	28.95	30.26

D1 frontal curvature in diopters, t central thickness in mm, facet in percentage

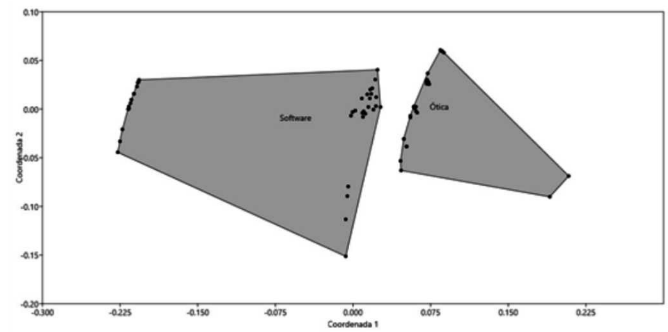

Figure 1: . Graphical representation of the parameter variations of the digital and iseonic surfacing lenses obtained by means of non-metric multidimensional multivariate analyzes, N-MDS, with Euclidean distance (stress = 0.053)

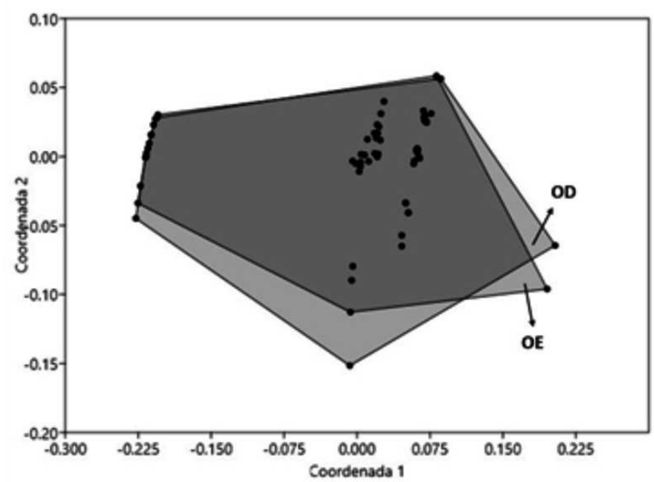

Figure 2: Graphical representation of the parameter variations of the digital and iseonic surfacing lenses obtained by means of non-metric multidimensional multivariate analyzes, N-MDS, showing that in the reduced space of the N-MDS order there is no statistically significant influence of the right or left eye factor (stress = 0.055)

Table 3
Results of the values (average and standard deviation) of vertical and horizontal aniseiconia measured with the use of digital (Optic) and iseonic (Software) surfacing lenses

Aniseiconia	Optic	Software	df	P-value
Vertical	-1.05% (2.20%)	-1.37% (2.36%)	18	0.82739
Horizontal	-0.89% (2.23%)	-1.16% (2.03%)	18	0.77018

Paired Student t test

Table 4
Results of the evaluation of steropsia by the Titmus test in the use of digital (optical) and iseonic (Software) surfacing lenses – ration of students <100 seconds of arc of stereopsia/total

Correction	N	<100	Average	(SD)	t	Df	P-value
Optic	19	21.1%	0.21	(0.42)	0.722	18	0.475
Software	19	31.6%	0.32	(0.48)			

Paired Student t test

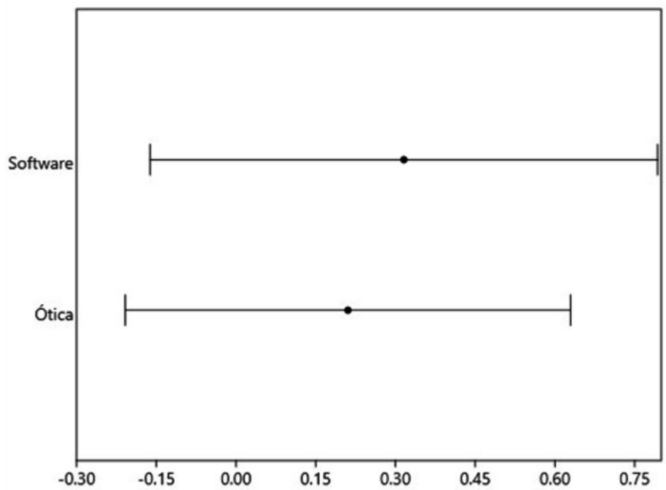

Figure 3: Graphical representation of the ratio of students with less than 100 seconds of arc of stereopsia/total in use of digital (Optic) and iseiconic lenses (Software)

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