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Association between Anisometropia as Well as Visual Acuity, Aniseikonia, and Stereopsis in the Absence of Strabismus

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Abstract

Objective: The current study aimed to assess the association between the type of anisometropia and its effects on monocular and binocular best-corrected vision acuity (BCVA), aniseikonia, and stereopsis in the absence of strabismus. **Methods:** In total, 162 individuals with anisometropia and healthy eyes and without a previous history of amblyopia therapy and eye surgery were included in the analysis. According to spherical and cylindrical components and spherical equivalent, they were divided into the spherical hyperopic anisometropia (SHA, n = 31), spherical myopic anisometropia (SMA, n = 45), astigmatic or cylindrical hyperopic anisometropia (CHA, n = 22), and astigmatic or cylindrical myopic anisometropia (CMA, n = 64) groups. Patients without anisometropia (NA, n = 188) were classified under the control group. The effects of anisometropia on monocular and binocular BCVA, aniseikonia, and stereoacuity were examined. **Results:** The NA group had a significantly lower LogMAR of BCVA of the right eye (RE), left eye (LE), worse eye than the SHA, SMA, CMA, and CHA groups. Moreover, the SMA group had significantly lower LogMAR of BCVA than the CHA group ($p < 0.05$). However, there was no significant difference between the groups in terms of the descriptive values of aniseikonia ($p = 0.052$). The NA group had significantly lower stereoacuity values in $\log_{10}$ arc seconds than the CHA ($p < 0.05$), CMA ($p < 0.05$), and SMA ($p < 0.05$) groups. The SMA groups had significantly lower stereoacuity values in $\log_{10}$ arc seconds than the CMA ($p < 0.05$) and SHA ($p < 0.05$) groups. There was a significantly positive correlation in the anisometropia group between aniseikonia and stereoacuity values in $\log_{10}$ arc seconds ($r = 0.160$; $p = 0.041$). **Conclusion:** Worse visual levels of the RE, LE, worse eye, BCVA difference, and lower stereopsis were

evidenced in each type of anisometropia defined in this study. Cylindrical hyperopic anisometropia (CHA) resulted in a statically significant worsening VA level and stereopsis than cylindrical myopic (CMA) or spherical myopic anisometropia.

Keywords

Anisometropia, Visual Acuity, Aniseiconia, Stereoacuity, Depth Perception

1. Introduction

Anisometropia develops when there is a significant difference in refractive error between the two eyes [1] [2]. The prevalence of anisometropia in the general population, which is based on the sample assessed and the criterion adopted, is approximately 5.6% [3].

Aniseikonia is a binocular vision disorder in which images perceived by the two eyes differ in size and/or shape and can be optically induced by spectacles used in the correction of anisometropia [4]. Currently, anisometropia is the most common cause of aniseikonia [5]. A clear association between increasing anisometropia and decreasing stereoacuity has been observed in normal participants in experimental studies [6] [7] [8] [9] [10]. The current study aimed to assess the association between the type of anisometropia and its effects on monocular and binocular BCVA, aniseikonia, and stereopsis.

2. Methods

This research was approved by the Ethics Committee for Analysis of Research Projects of the Faculty of Medicine of University of São Paulo (process: 43036320.8.3001.0068). Moreover, it was performed in accordance with the principles of the Declaration of Helsinki. The study details were explained to the participants, and they or their guardians provided a written informed consent before enrolment.

2.1. Participants

A cross-sectional observational study was conducted on 280 individuals with healthy eyes and without a previous history of amblyopia therapy or eye surgery at a tertiary care teaching hospital in Manaus, Brazil, from March 2021 to January 2022. All participants underwent complete ophthalmic examination with visual acuity (VA) recording for best-corrected visual acuity (BCVA) in LogMAR for near and far vision. Then, the cover/uncover test (which is performed to evaluate extrinsic ocular motility), assessment with striated Bagolini lenses, biomicroscopic in slit lamp (Haag-Streit AT 900), cycloplegic refraction with 1% cyclopentolate, tonometry (AT 900, MedVision), and direct (Pocket Junior®), Welch Allyn and indirect (ODS®6.0 EyeTec) fundoscopy were performed. Moreover, all spectacles were updated.

2.2. Inclusion Criteria

Female and male individuals aged between 9 and 63 years with pure refractive error (no other ocular pathology), sensory fusion evaluated using Bagolini striated lenses, intraocular pressure of <20 mmHg without medication, excavation of the optic nerve at <0.7, and normal fundoscopy findings were included.

2.3. Exclusion Criteria

Contact lens users, individuals with previous ocular surgery and any ocular pathology including strabismus, and those with other pre-existing eye diseases that could alter the BCVA (such as moderate or intense dry eye, uveitis, glaucoma, and degenerative retinal disease) were excluded.

2.4. Group Criteria

Individuals with anisometropia were divided into the spherical hyperopic anisometropia (SHA), spherical myopic anisometropia (SMA), astigmatic or cylindrical hyperopic anisometropia (CHA), and astigmatic or cylindrical myopic anisometropia (CMA) groups [2]. Patients with ≤1 DC of cylindrical anisometropia were analyzed based on spherical equivalents (SEs) alone and were included in either the myopic or the hyperopic spherical groups if the interocular difference in SE was ≥1 D [2]. The participants were classified under the SHA or SMA group based on the presence of a more ametropic eye [2]. The values for astigmatic or cylindrical anisometropia have been calculated as the difference between the astigmatic error of the two eyes (≥1 DC), and the axis of astigmatism was not considered in calculating the degree of astigmatism anisometropia [2]. The cylindrical interocular difference in the control group was <1 DC, and the SE interocular difference was <1 D [2].

2.5. Study Procedure

On the subsequent visit, BCVA, aniseikonia, and stereoacuity were evaluated. BCVA was examined using updated glasses and the EDTRS chart for adults (com 0.1 log progression of letter size). Subjective aniseikonia was assessed using the Aniseikonia Inspector version 3. Aniseikonia was investigated using optical correction and green and red filters to dissociate the images of the two eyes. The participants were positioned 45 cm in front of the computer monitor. At the start of the test, they pointed at the computer screen and determined which of the two rectangular boxes was wider and taller. If the images looked similar, the examiner selected the "E" button. The examination results were obtained in magnification/minification percentage in the vertical and horizontal meridians, along with a consistency value that considered the reliability or inconsistency of the results. We used the median values taken in horizontal and vertical directions in the 8˚ visual fields.

The stereoacuity was examined using the Randot® stereo test (Stereo Optical Company, Inc., the USA) under the best refractive correction, and polaroid

glasses at a 40-cm distance. Individuals were instructed to identify the circle, which was different from the other, in a group of four circles. During stereoacuity determination, if the individual could not identify the correct circle for two consecutive times, then the previous result was considered as the examinee's stereoacuity. For analysis purposes, arc seconds have been transformed into units of logarithm at the base of 10. Each doubling of the stereoacuity threshold (e.g., 100 - 200 arc seconds, corresponds to a change of 0.3 from $\log_{10}$ of the transformed value).

2.6. Sample Size

A sample size of 22 was required for each group to identify stereoacuity differences of 0.30 units of $\log_{10}$ arc seconds with a statistical power of 80% and a significance level of 0.05 between groups. The calculations were performed with the *t*-test and the difference between two independent means using G*Power 3.1.9.4.

2.7. Statistical Analysis

Initially, all variables were analyzed descriptively. For quantitative variables, analysis was performed by calculating means, standard deviations, and median values. For qualitative variables, absolute and relative frequencies were calculated. Data normality was assessed using the Kolmogorov–Smirnov test [11]. Variance analysis was conducted to compare the means of the groups to a factor with multiple comparisons using the Bonferroni test [11]. If the assumption of data normality was rejected, the Kruskal–Wallis nonparametric test was used with multiple comparisons using the Dunn test [11]. The chi-square test was applied to examine homogeneity between the proportions [11]. A correlation study was performed via Spearman correlation analysis. The Statistical Package for the Social Sciences software version 17.0 for Windows. The significance level used for the tests was 5%.

3. Results

In total, 280 individuals aged between 9 and 59 years were included in the study. Among them, 164 (58.6%) were women and 116 (41.4%) men. According to the spherical and cylindrical components and SEs, they were divided into the SHA (n = 31, 11.1%), SMA (n = 45, 16.1%), CHA (n = 22, 7.94%), CMA (n = 64, 22.8%), and control (NA) (n = 118, 42.1%) groups. **Table 1** presents the descriptive variables used for group classification.

Table 2 and **Table 3** show the difference in terms of age and sex among the groups. The groups significantly differed in terms of age (analysis of variance to one factor, $p < 0.001$). Using the Bonferroni test, the NA and SMA groups were found to be significantly younger than the CHA ($p < 0.05$) and SHA ($p < 0.05$) groups (**Table 2**).

The groups significantly differed in terms of sex (chi-square test, $p = 0.041$). Using the chi-square partition, the NA and SMA groups had a significantly lower

Table 1. Descriptive values of interocular differences in spherical equivalents (D) and cylindrical components (DC) according to the study groups.

Groups	n	Mean ± SD	Median
SHA (a)	31	2.51 ± 2.87	1.50
SMA (a)	45	1.87 ± 0.98	1.50
CHA (b)	22	2.57 ± 2.76	1.88
CMA (b)	64	2.63 ± 1.70	1.88
NA (a)	118	0.34 ± 0.23	0.25
NA (b)	118	0.32 ± 0.32	0.25

(a) Interocular difference in spherical equivalent. (b) Interocular difference in cylindrical components.

Table 2. Descriptive values of age (years) according to the study groups.

Groups	n	Mean ± SD	Range	p value*
SHA	31	39.61 ± 14.70	9 - 52	<0.001
SMA (a) (b)	45	30.58 ± 11.70	11 - 52	
CHA	22	41.28 ± 14.03	12 - 59	
CMA	64	33.90 ± 10.27	11 - 55	
NA (a) (b)	118	30.22 ± 13.31	9 - 59	

(*) Descriptive level of probability of variance analysis to a factor. (a) Significant difference in the CHA group ($p < 0.05$). (b) Significant difference in the SHA group ($p < 0.05$).

Table 3. Absolute and relative frequencies of sex according to the study groups.

Sex	Female		Male		p value*
Groups	n	%	n	%	
SHA	18	58.1	13	41.9	0.041
SMA (a) (b) (c)	22	48.9	23	51.1	
CHA	13	59.1	9	40.9	
CMA	45	70.3	19	29.7	
NA (a) (b) (c)	62	52.5	56	47.5	

(*) Descriptive level of probability of the chi-square test. (a) Significant difference between groups ($p < 0.05$). (b) Significant difference between groups ($p < 0.05$). (c) Significant difference between groups ($p < 0.05$).

number of female participants than the CHA, CMA, and SHA groups ($p = 0.005$). There was no significant difference between the NA and SMA groups ($p = 0.672$) and between the CMA, CHA, and SMA groups ($p = 0.397$) (Table 3).

Table 4 shows the descriptive BCVA values according to the study groups.

The mean BCVA of the two eyes varied between 0.30 and 0.86 LogMAR. The groups significantly differed in terms of the LogMAR of BCVA in the two eyes, and there was a remarkably significant difference in BCVA (Kruskal–Wallis

nonparametric test, $p < 0.001$). Using the Dunn's test, the NA group was found to have a significantly lower LogMAR of BCVA in the two eyes than the other groups, and the SMA group had a significantly lower LogMAR of BCVA than the CHA group ($p < 0.05$). The SMA group had a lower BCVA difference than the CMA group ($p < 0.05$) (Table 4).

Table 5 depicts the descriptive values of aniseikonia according to the study groups. There was no significant difference between the groups according to the descriptive values of aniseikonia ($p = 0.052$).

Table 6 shows the descriptive values of stereoacuity according to the study groups.

The mean stereoacuity values varied between 1.71 $\log_{10}$ arc seconds or 50 arc seconds, and 2.21 $\log_{10}$ arc seconds or 160 arc seconds. The groups significantly differed in terms of the descriptive values of stereoacuity (Kruskal-Wallis nonparametric test, $p < 0.001$). Using the Dunn's test, the NA group had significantly

Table 4. Descriptive LogMAR of BCVA (LE and RE) and the difference between the two eyes and worse eye according to the study groups.

Variables	Groups	N	Mean ± SD	Median	p value*
BCVA LE	SHA (a)	31	0.59 ± 0.25	0.50	<0.001
	SMA (a)	45	0.50 ± 0.19	0.50	
	CHA (a) (b)	22	0.79 ± 0.29	0.70	
	CMA (a)	64	0.60 ± 0.35	0.60	
	NA	118	0.30 ± 0.19	0.30	
BCVA RE	SHA (a)	31	0.69 ± 0.27	0.70	<0.001
	SMA (a)	45	0.54 ± 0.25	0.50	
	CHA (a) (b)	22	0.86 ± 0.34	0.70	
	CMA (a)	64	0.62 ± 0.35	0.55	
	NA	118	0.30 ± 0.19	0.30	
BCVA difference	SHA (a)	31	0.17 ± 0.20	0.10	<0.001
	SMA (a)	45	0.08 ± 0.14	0.00	
	CHA (a)	22	0.24 ± 0.24	0.20	
	CMA (a) (b)	64	0.23 ± 0.27	0.10	
	NA	118	0.00 ± 0.01	0.00	
BCVA Worst Eye	SHA (a)	31	0.73 ± 0.28	0.70	<0.001
	SMA (a)	45	0.56 ± 0.25	0.50	
	CHA (a) (b)	22	0.95 ± 0.27	1.00	
	CMA (a)	64	0.73 ± 0.37	0.65	
	NA	118	0.30 ± 0.19	0.30	

(*) Descriptive level of probability using the Kruskal–Wallis nonparametric test. (a) Significant difference in the NA group ($p < 0.05$). (b) Significant difference in the SMA group ($p < 0.05$).

Table 5. Descriptive values of aniseikonia (%) according to the study groups.

Groups	n	Mean ± SD	Median	p value*
SHA (a)	31	4.10 ± 3.70	3.00	0.052
SMA	45	2.77 ± 1.89	2.33	
CHA (a) (b)	22	5.58 ± 4.27	4.26	
CMA (a) (b)	64	3.38 ± 3.57	2.00	
NA	118	2.52 ± 1.79	2.50	

(*) Descriptive level of probability using the Kruskal–Wallis nonparametric test. (a) Significant difference in the NA group ($p < 0.05$). (b) Significant difference in the SMA group ($p < 0.05$).

Table 6. Descriptive values of stereoacuity in $\log_{10}$ arc seconds according to the study groups.

Groups	n	Mean ± SD	Median	p value*
SHA (a)	31	1.96 ± 0.45	1.70	<0.001
SMA	45	1.78 ± 0.36	1.60	
CHA (a) (b)	22	2.21 ± 0.51	2.15	
CMA (a) (b)	64	2.08 ± 0.52	1.90	
NA	118	1.71 ± 0.27	1.60	

(*) Descriptive level of probability of the Kruskal–Wallis nonparametric test. (a) Significant difference in the NA group ($p < 0.05$). (b) Significant difference in the AEM group ($p < 0.05$).

lower descriptive values of stereoacuity in $\log_{10}$ arc seconds than the CHA ($p < 0.05$), CMA ($p < 0.05$), and SMA ($p < 0.05$) groups. Moreover, the descriptive values of stereoacuity in $\log_{10}$ arc seconds were significantly lower in the SMA group than in the CMA ($p < 0.05$) and SHA ($p < 0.05$) groups (Table 6).

Table 7 shows the descriptive values of aniseikonia and stereoacuity concerning anisometropia and control groups.

We observed that the groups present significant differences concerning the stereoacuity ($p < 0.001$, Table 7). Using Spearman's correlation coefficient, we found no significant correlation between stereoacuity and aniseikonia in the NA group ($r = 0.058$; $p = 0.535$) and a significantly positive association between the values of stereoacuity in $\log_{10}$ arc seconds and aniseikonia in the anisometropia group ($r = 0.281$; $p < 0.001$, Figure 1 and Figure 2).

4. Discussion

Anisometropia is the primary cause of amblyopia [12]. In this study, the mean BCVA of the two eyes varied between 0.30 and 0.83 LogMAR. The NA group had a significantly lower LogMAR of BCVA in the two eyes than the other groups. Moreover, the SMA group had a significantly lower LogMAR of BCVA than the CHA group ($p < 0.05$) (Table 4).

Table 7. Descriptive values of aniseikonia and stereoacuity in the anisometropia and control groups.

Variables	Groups	n	Mean ± SD	Median	p value*
Aniseikonia	Anisometropia	162	3.59 ± 3.38	2.41	0.621
	NA	118	2.52 ± 1.79	2.50	
Stereoacuity	Anisometropia	162	1.99 ± 0.48	1.78	
	NA	118	1.71 ± 0.27	1.60	<0.001

NA: control group, n: number of cases, (*) descriptive level of probability of the Mann–Whitney nonparametric test.

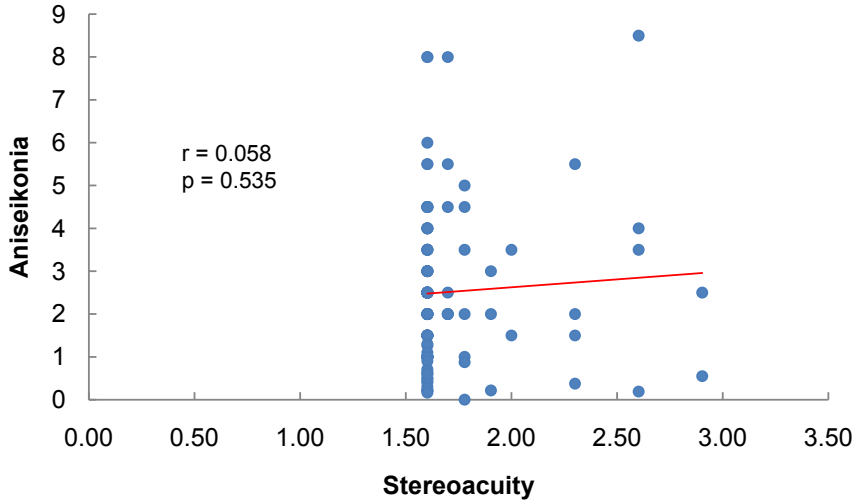

Figure 1. Correlation between stereoacuity ($\log_{10}$ arc seconds) and aniseiconia (%) in the control group (r = 0.058; p = 0.535).

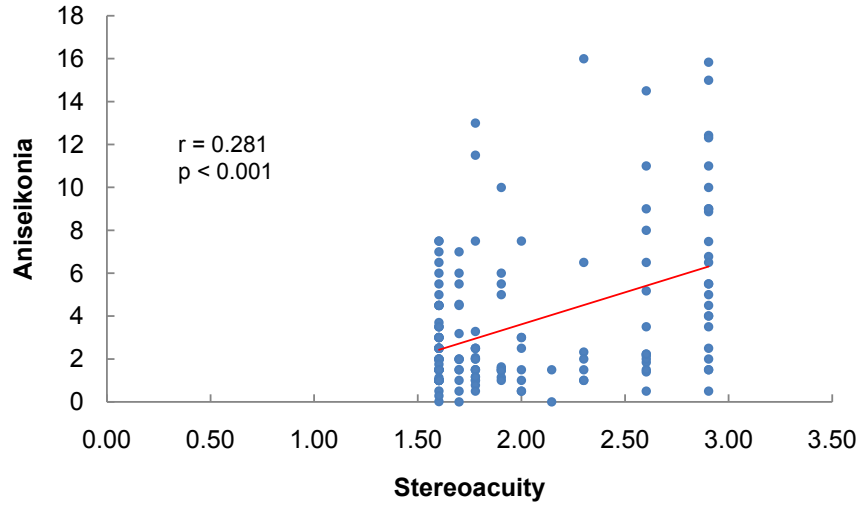

Figure 2. Correlation between stereoacuity ($\log_{10}$ arc seconds) and aniseiconia (%) in the anisometropia group (r = 0.281; p < 0.001).

Copps [13] initially validated the association between pure anisometropia (anisometropia in the absence of strabismus) and amblyopia in 44 patients with

≥1 D (SE) of anisometropia. Results showed that it was more likely hyperopic than myopic anisometropia. These findings were later confirmed by Jampolsky [14]. Moreover, Copps [13] and Jampolsky [14] showed that patients with increasing amounts of anisometropia had decreasing BCVA in the worse eye.

In this study, the mean difference in BCVA in each group was recorded as LogMAR, ranging from 0.00 (NA group) to 0.24 (CHA group) (**Table 4**). VA measurements using the LogMAR chart have been found to be twice as repeatable as those from the Snellen chart [15] and over three times more sensitive to interocular differences in VA. Therefore, it is significantly more sensitive to amblyopic changes [16].

Spectacle correction alone in anisometropia has improved VA (and presumably anisometropic amblyopia) over time [17]. Therefore, in this research, the BCVA data were obtained with updated eyeglass correction during the second office visit, and there were no improvements in any existing amblyopia.

Considerably less attention has been paid to the association between anisometropia and binocularity than to the correlation between anisometropia and monocular acuity or amblyopia [18]. Previous studies examining the effects of naturally occurring anisometropia rarely addressed the issue of binocularity [19].

In this study, we did not observe a significant difference between the groups in terms of aniseikonia ($p = 0.973$, **Table 5**). Theoretically, there was a linear 1:1 correlation between anisometropia and optical aniseikonia. However, Krarup *et al.* [20] did not find a 1:1 correlation between anisometropia and aniseikonia, as in this study. Other studies have described difficulty in finding a significant correlation between anisometropia and perceived aniseikonia [21] [22]. This challenge may be attributed to the adaptation of the visual system. In the study of Burian [23], the adaptation rate was 1.5% - 6% after 3 - 4 days in a focal iseikonic lenses-induced aniseikonia. Adaptation to aniseikonia could explain the findings of previous electrophysiological and psychophysical studies [24] [25] [26] in which there was a significant adaptation of short-term stereopsis in 3% aniseikonia induced by afocal iseikonic lenses.

If the optical correction of anisometropia is intended to treat aniseikonia, parameters (base curve, thickness, vertex distance, and refractive index) can be manipulated to modify the size of the retinal image [27] [28] [29]. Nomograms and complicated calculations are not always necessary, with consideration that the frontal curvature may be the most important modifiable factor [27]. Primiano Jr *et al.* [30] conducted a study in 2019. Results showed that the optical correction findings in students with anisometropia with stock lenses with base curves selected to minimize the interocular size difference between retinal images were similar to those in students with iseikonic lenses, as shown using Aniseikonia Inspector 3.

The NA group had a significantly lower stereoacuity in $\log_{10}$ arc seconds (or stereopsis higher) than the CHA ($p < 0.05$), CMA ($p < 0.05$), and SMA ($p < 0.05$) groups. Further, the SMA group presented with a significantly lower stereoacuity than the CMA ($p < 0.05$) and SHA ($p < 0.05$) groups. The stereoacuity of the

NA group was 1.71 ± 0.27 $\log_{10}$ arc seconds, and this value corresponded to approximately 50 arc seconds. The approximate values in the other groups were as follows: SMA, 60 arc seconds; SHA, 90 arc seconds; CMA, 120 arc seconds; and CHA, 160 arc seconds. Moreover, the normal stereopsis is commonly 40 - 60 arc seconds [31] [32] [33] [34].

The range of 60 - 100 arc seconds is considered normal and 100 - 400 arc seconds as subnormal binocularity [35]. In a previous study, the stereoacuity levels reduced in proportion to the degree of anisometropia in all patients. Further, 1 D of spherical anisometropia reduced stereoacuity to an average of 57 - 59 arc seconds. Further, 1 D of cylindrical anisometropia decreased stereoacuity to an average of 51 - 56 arc seconds, and 3 D of anisometropia, regardless of type, resulted in the significant reduction of stereoacuity in all patients [36]. Some studies have shown a slight decline in stereopsis with age among people aged 17 - 83 years, and this finding was more likely to be attributed to fusional capacity failure than stereopsis deficiency at the cortical level [37].

Stereopsis is essential for seeing the world in three dimensions, and it also plays a key role in visuomotor skills [38]. The loss of stereopsis affects the performance of several daily motor skills necessary to perform nearby tasks such as manipulation of objects and distance such as driving and sports [10]. This study showed that both spherical and cylindrical anisometropia had an impact on significant diminution in stereopsis.

Patients with anisometropia and controls significantly differed in terms of stereoacuity, but not aniseikonia ($p < 0.001$, **Table 7**). Using Spearman's correlation coefficient, we found no significant correlation between stereoacuity and aniseikonia ($r = 0.058$; $p = 0.535$) in the NA group (**Figure 1**). However, there was a positive and significant correlation between aniseikonia and stereoacuity in $\log_{10}$ arc seconds in the anisometropia group ($r = 0.281$; $p < 0.001$; **Figure 2**).

In the research of Krarup *et al.* [19], the surgical task score significantly decreased with increasing anisometropia, and there was a negative correlation between an increase in the mean arc seconds assessed using the Randot® stereo test and both spherical anisometropia and cylindrical anisometropia were associated with decreased stereoacuity. Moreover, the reduction in test scores was significant even at 1 D of anisometropia. Therefore, even a small degree of anisometropia could cause a substantial loss in surgical dexterity, as tested in a simulated environment.

The current study had several limitations. That is, only individuals of varying ages who were not treated previously for amblyopia were included. Some conclusions regarding the nature of the effect of anisometropia corrected on the visual system can be drawn from the evaluation of the patients in this study: a trend for worsening acuity in the RE, LE, BCVA difference and Worst Eye, and worsening stereoacuity in each type of anisometropia defined in this study. Cylindrical hyperopic anisometropia (CHA) resulted in a statically significant worsening visual acuity level and stereoacuity than cylindrical myopic (CMA) or spherical myopic anisometropia.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Duman, R., Atilla, H. and Çatak, E. (2018) Characteristics of Anisometropic Patients with and without Strabismus. *Turkish Journal of Ophthalmology*, **48**, 23-26. https://doi.org/10.4274/tjo.44342

[2] Weakley, D.R. (1999) The Association between Anisometropia, Amblyopia, and Binocularity in the Absence of Strabismus. *Transactions of the American Ophthalmological Society*, **97**, 987-1021.

[3] Moghaddam, O., Fotouhi, A., Hashemi, H. and Yekta, A. (2012) The Prevalence of Anisometropia in Population Base Study. *Strabismus*, **20**, 152-157. https://doi.org/10.3109/09273972.2012.680229

[4] South, J., Gao, T., Collins, A., Lee, A., Turuwhenua, J. and Black, J. (2020) Clinical Aniseikonia in Anisometropia and Amblyopia. *British and Irish Orthoptic Journal*, **16**, 44-54. https://doi.org/10.22599/bioj.154

[5] Dadeya, S. and Kamlesh, S.F. (2001) The Effect of Anisometropia on Binocular Visual Function. *Indian Journal of Ophthalmology*, **49**, 261-263.

[6] Atchison, D.A., Lee, J., Lu. J., Webber, A.L., Hess, R.F., Baldwin, A.S. and Schmid, K.L. (2020) Effects of Simulated Anisometropia and Aniseikonia on Stereopsis. *Ophthalmic & Physiological Optics*, **40**, 323-332. https://doi.org/10.1111/opo.12680

[7] Momeni, M.H., Ansarei, H., Yekta, A. and Sargolzaei, M. (2008) The Effect of Anisometropia on Stereopsis. *Journal of Shahrekord University of Medical Sciences*, **10**, 52-58. http://78.39.35.44/article-1-10-en.html

[8] Brooks, S.E., Johnson, D. and Fischer, N. (1996) Anisometropia and Binocularity. *Ophthalmology*, **103**, 1139-1143. https://doi.org/10.1016/S0161-6420(96)30555-1

[9] Gawecki, M. and Adamski, J. (2004) Anisometropia and Stereopsis. *Klinika Oczna*, **106**, 561-563.

[10] Singh, P., Bergaal, S.K., Sharma, P., Agarwal, T., Saxena, R. and Phuljhele, S. (2021) Effect of Induced Anisometropia on Stereopsis and Surgical Tasks in a Simulated Environment. *Indian Journal of Ophthalmology*, **69**, 568-572. https://doi.org/10.4103/ijo.IJO_1540_20

[11] Rosner, B. (1986) Fundamentals of Biostatistics. Second Edition, PWS Publishers, Boston, 584.

[12] Barrett, B.T., Bradley, A. and Candy, T.R. (2013) The Relationship between Anisometropia and Amblyopia. *Progress in Retinal and Eye Research*, **36**, 120-158. https://doi.org/10.1016/j.preteyeres.2013.05.001

[13] Copps, L.A. (1944) Vision in Anisometropia. *American Journal of Ophthalmology*, **27**, 641-644. https://doi.org/10.1016/S0002-9394(44)91523-0

[14] Jampolsky, A., Flom, B.C., Weymouth, F.W. and Moses, L.E. (1955) Unequal Corrected Visual Acuity as Related to Anisometropia. *Archives of Ophthalmology*, **54**, 893-905. https://doi.org/10.1001/archopht.1955.00930020899013

[15] Lovie-Kitchin, J.E. (2015) Is It Time to Confine Snellen Charts to the Annals of History? *Ophthalmic & Physiological Optics*, **35**, 631-636. https://doi.org/10.1111/opo.12252

[16] McGraw, P.V., Winn, B., Gray, L.S. and Elliott, D.B. (2000) Improving the Reliability of Visual Acuity Measures in Young Children. *Ophthalmic & Physiological Optics*, **20**, 173-184. https://doi.org/10.1046/j.1475-1313.2000.00497.x

[17] Moseley, M.J., Neufeld, M., McCarry, B., Charnock, A., McNamara, R., Rice, T. and Fielder, A. (2002) Remediation of Refractive Amblyopia by Optical Correction Alone. *Ophthalmic & Physiological Optics*, **22**, 296-299. https://doi.org/10.1046/j.1475-1313.2002.00034.x

[18] Smith, E.L., Hung, L.F., Arumugam, B., Wensveen, J.M., Chino, Y.M. and Harwerth, R.S. (2017) Observations on the Relationship between Anisometropia, Amblyopia and Strabismus. *Vision Research,* **134**, 26-42. https://doi.org/10.1016/j.visres.2017.03.004

[19] Krarup, T., Nisted, I., Kjaerbo, H., Christensen, U., Kiilgaard, J.F. and la Cour, M. (2021) Measuring Aniseikonia Tolerance Range for Stereoacuity—A Tool for the Refractive Surgeon. *Acta Ophthalmologica*, **99**, e43-e53. https://doi.org/10.1111/aos.14507

[20] Krarup, T.G., Nisted, I., Christensen, U., Kiilgaard, J.F. and la Cour, M. (2020) The Tolerance of Anisometropia. *Acta Ophthalmologica*, **98**, 418-426. https://doi.org/10.1111/aos.14310

[21] Rutstein, R.P., Fullard, R.J., Wilson, J.A. and Gordon, A. (2015) Aniseikonia Induced by Cataract Surgery and Its Effect on Binocular Vision. *Optometry and Vision Science*, **92**, 201-207. https://doi.org/10.1097/OPX.0000000000000491

[22] Miyake, S., Awaya, S. and Miyake, K. (1981) Aniseikonia in Patients with a Unilateral Artificial Lens, Measured with Aulhorn's Phase Difference Haploscope. *Journal—American Intra-Ocular Implant Society*, **7**, 36-39. https://doi.org/10.1016/S0146-2776(81)80095-X

[23] Burian, H.M. (1943) Clinical Significance of Aniseikonia. *Archives of Ophthalmology*, **29**, 116-133. https://doi.org/10.1001/archopht.1943.00880130136010

[24] Levi, D.M., McKee, S.P. and Movshon, J.A. (2011) Visual Deficits in Anisometropia. *Vision Research,* **51**, 48-57. https://doi.org/10.1016/j.visres.2010.09.029

[25] Stewart, C. and Whittle, J. (1996) Optical Correction of Aniseikonia in Anisometropia Can Enhance Stereoacuity. *Binocular Vision & Strabismus Quarterly*, **12**, 31-34.

[26] Campos, E.C. and Enoch, J.M. (1980) Amount of Aniseikonia Compatible with Fine Binocular Vision: Some Old and New Concepts. *Journal of Pediatric Ophthalmology and Strabismus*, **17**, 44-47. https://doi.org/10.3928/0191-3913-19800101-11

[27] Sousa, S.J. (2002) Revisando as Anisometropias. *Arquivos Brasileiros de Oftalmologia*, **65**, 114-117. https://doi.org/10.1590/S0004-27492002000100023

[28] Tayah, D., Coral-Ghanem, V. and Alves, M.R. (2007) The Ocular Components in Anisometropia. *The Arquivos Brasileiros de Oftalmologia*, **70**, 459-464. https://doi.org/10.1590/S0004-27492007000300013

[29] Kulp, M.A., Raasch, T.W. and Polasky, M. (2006) Patients with Anisometropia and Aniseikonia. In: Benjamin, W.J., Ed., *Borish's Clinical Refraction*, Elsevier, Houston, 1479-1522. https://doi.org/10.1016/B978-0-7506-7524-6.50037-5

[30] Primiano Jr., H.P., Orlandin, L.F., Takatsu, M.V., Alves, M.R.R.A. and Alves, M.R. (2019) Tratamento da aniseiconia induzida na correção óptica de anisometropia em escolares do ensino fundamental. *Revista Brasileira de Oftalmologia*, **78**, 255-259.

[31] Katsumi, O., Tanino, T. and Hirose, T. (1986) Effect of Aniseikonia on Binocular Function. *Investigative Ophthalmology & Visual Science*, **27**, 601-604.

[32] Oguchi, Y. and Mashima, Y. (1989) The Influence of Aniseikonia on the VEP by

Random-Dot Stereogram. *Acta Ophthalmologicaogica* (*Copenh*), **67**, 127-130. https://doi.org/10.1111/j.1755-3768.1989.tb00740.x

[33] Lubkin, V., Stollerman, H. and Linksz, A. (1966) Stereopsis in Monocular Aphakia with Spectacle Correction. *American Journal of Ophthalmology*, **61**, 273-276. https://doi.org/10.1016/0002-9394(66)90282-0

[34] Jiménez, J.R., Ponce, A., del Barco, L.J., Díaz, J.A. and Pérez-Ocón, F. (2002) Impact of Induced Aniseikonia on Stereopsis with Random-Dot Stereogram. *Optometry and Vision Science*, **79**, 121-125. https://doi.org/10.1097/00006324-200202000-00014

[35] Lee, J.Y., Seo, J.Y. and Baek, S.U. (2013) The Effects of Glasses for Anisometropia on Stereopsis. *American Journal of Ophthalmology*, **156**, 1261-1266. https://doi.org/10.1016/j.ajo.2013.07.016

[36] Oguz, H., Oguz, V.T. (2000) The Effects of Experimentally Induced Anisometropia on Stereopsis. *Journal of Pediatric Ophthalmology and Strabismus*, **37**, 214-218. https://doi.org/10.3928/0191-3913-20000701-08

[37] Kramer, P.W., Lubkin, V., Pavlica, M. and Covin, R. (1999) Symptomatic Aniseikonia in Unilateral and Bilateral Pseudophakia. A Projection Space Eikonometer Study. *Binocular Vision & Strabismus Quarterly*, **14**, 183-190.

[38] Sharma, P. (2017) The Pursuit of Stereopsis. *Journal of AAPOS*, **22**, 2.e1-2.e5. https://doi.org/10.1016/j.jaapos.2017.10.009