

THE ASSOCIATION BETWEEN ASTIGMATIC ANISOMETROPIA WITH VISUAL ACUITY AND STEREOPSIS

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ABSTRACT

Aim: To study the association between astigmatic anisometropia with visual acuity (VA) and stereopsis.

Methodology: Twenty emmetropic adults with normal binocularity in age of 18 to 34 years old, were recruited. Unilateral against-the-rule astigmatism anisometropia was induced in each participant by using -1DC, -2DC, -3DC and -4DC toric soft contact lenses. Distance VA is measured using logMAR chart, near VA is measured using Roman Test types chart, and stereopsis using TNO plates were assessed.

Results: All participants showed a reduction in VA at distance and near, and stereopsis with the increasing values of astigmatic anisometropia by using correlation analysis. The correlation of induced astigmatic anisometropia with distance VA was a weak positive correlation, ($r = 0.589$, $p = <0.05$), and moderate positive correlation ($r = 0.602$, $p = <0.05$) with near VA. Stereopsis was similarly degraded and showed weak positive correlation ($r = 0.589$, $p = <0.05$). Both acuities showed significant reduction in each 1D increment of astigmatic anisometropia by 1 line, meanwhile stereopsis showed significant reduction by 2 lines. Stereopsis is affected the most. All parameters reduction can be predicted by using linear regression equation obtained, at any degree of astigmatic anisometropia.

Conclusion: Increment in induced astigmatic anisometropia shown linear reduction in distance VA, near VA and stereopsis.

KEYWORDS: Astigmatic Anisometropia; Induced Anisometropia; Visual Acuity; Stereopsis.

INTRODUCTION

Anisometropia is a condition when there are unequal refractive errors between both eyes that will cause unequal focus and unequal VA. A patient can be considered as anisometropia when the refractive errors between the eyes are different by 1 Diopter (Yekta, et al. 2010). Anisometropia can be divided into four types; aniso-astigmatism, anisomyopia, anisohyperopia, and antimetropia.

Aniso-astigmatism is a condition when the astigmatism of an eye is different from another eye. Astigmatism is a defect in the structure of the eye whereby the rays of light do not converge to a point upon the retina (Colman, 2015). It occurs when the shape of the cornea or the shape of the crystalline lens is irregular.

Anisometropia always associated with aniseikonia. Aniseikonia, a condition of the binocular vision in which there is relative difference in the sizes or shapes of the two ocular images. The perceived image sizes in the visual cortex will be determined by a combination of factors including optical factors (the retinal image size), and anatomical and physiological factors (the topographical projection of the retinas onto the cortex) (South, et al., 2019; McNeill, et al., 2017; Winn et al. 1988). Since the retinal images of the two eyes perceived are not simultaneous at any viewing distance, the patient presumably developed relatively few binocular cortical neurons, that is most striate cells are expected to fall in ocular dominance categories 1 and 7 (Shwartz, 2004).

Anisometropia commonly occurs in children and if left untreated (uncorrected) it will cause amblyopia. Amblyopia can be defined as the reduction in VA that is caused by optical, physical, or ocular alignment defect during early childhood (Brook, et al., 1996). Anisometropia, a difference in the optical properties of the two eyes, reflected in a different

spectacle prescription for the right and the left eye may be one of the optical cause of amblyopia (Tailor, et al., 2016). Refractive amblyopia occurs when there is active inhibition of the fovea and lack of adequate stimulation for neurophysiological development of visual pathways and visual cortex, V1 (Tailor, 2017).

However, there was lack of experimental study about how much VA and stereopsis affected at any degrees of astigmatic anisometropia. Therefore, this study will emphasize how much the effects of degrees of uncorrected astigmatic anisometropia might have on VA and binocular visual functions.

MATERIALS AND METHOD

This is a psychophysical experiment in which it can quantitatively measure the relationship between stimuli and perception (Pelli & Farell, 1995). Inducing different level of astigmatic anisometropia can affect the visual performance monocularly and binocularly in terms of VA and stereopsis. The data in this research will be obtained by recruiting 20 emmetropes with refractive errors ± 0.50 DS (Gupta, et al., 2014; Behndig, et al., 2012) that mimicked anisometropic eye.

Participation in this study was on voluntary basis and participants gave their consent accordance to the tenets in the Declaration of Helsinki. Participants were explained about the procedures that are involved in this study.

Healthy participants aged between 26.00 ± 8 years old with normal binocular vision and stereopsis were recruited. The participants were screened and to follow the inclusion and exclusion criteria.

Four different degrees of astigmatic anisometropia were induced, in random order, by inserting the following Soft Contact Lenses Aire Toric38 (Apple Vision, Malaysia) with parameters of 8.60 mm base curve and 14.20 mm total lens diameter (Young, 2014; Van der Worp, et al., 2014). The power of the lenses was -1.00 DC X 90, -2.00 DC X 90, -3.00 DC X 90, and -4.00 DC X 90. The lenses were inserted in the participants' dominant eye.

After 5 minutes of lens insertion, the fitting assessment was performed to ensure the contact lens was nicely fit on 90° axis (Wolffson, et al., 2009; Schwallie, et al., 1998; Brennan, et al., 1994). VA at 4m was taken by using LogMAR chart, considered as the distant VA. VA at near was also taken by using Roman Test Types near chart at 40 cm. Stereopsis was assessed by using TNO plates at 40cm. The subjects need to wore red-green goggles and record the result until which plate that the subject can see. VA at near results and stereopsis results then been converted to logMAR values, by using conversion table for near VA (Holladay, J., et al, 2004), and conversion equation for stereopsis;

$$\text{Stereopsis (logMAR)} = \log \frac{\text{min of arc}}{60}$$

The data were analyzed by using SPSS (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.). correlation analyses were employed to determine the correlation between VA and stereopsis in increasing degrees of induced astigmatic anisometropia. The linear regression analysis, to predict the value of VA and stereopsis based on induced astigmatism.

This study had ethically approved by IIUM KAHS Ethics Committee (KAHS 82/18) and also complied with the requirements of the Declaration of Helsinki.

RESULTS

(A) Correlation between induced astigmatic anisometropia and VA at distance, VA at near and stereopsis

The Pearson product-moment correlation was run to determine the relationship between induced astigmatism with VA at distance, VA at near, and stereopsis. There were positive correlation between induced astigmatism and VA at distance, VA at near, and stereopsis which were statistically significant ($r = 0.589, p = <0.05$), ($r = 0.602, p = <0.05$) and ($r = 0.589, p = <0.05$), respectively.

Table 1. Table of mean and standard deviation of effect of each degree of induced astigmatic anisometropia on VA at distance, VA at near and stereopsis.

Induced unilateral astigmatism	Mean \pm SD		
	VA at distance (logMAR)	VA at near (logMAR)	Stereopsis (logMAR)
Plano	0.00 \pm 0.00	0.18 \pm 0.0	-0.11 \pm 0.20
-1DC X 90	0.04 \pm 0.09	0.19 \pm 0.03	0.11 \pm 0.48
-2DC X 90	0.25 \pm 0.16	0.33 \pm 0.13	0.23 \pm 0.38
-3DC X 90	0.54 \pm 0.12	0.44 \pm 0.14	0.83 \pm 0.54
-4DC X 90	0.27 \pm 0.28	0.39 \pm 0.18	0.77 \pm 0.66

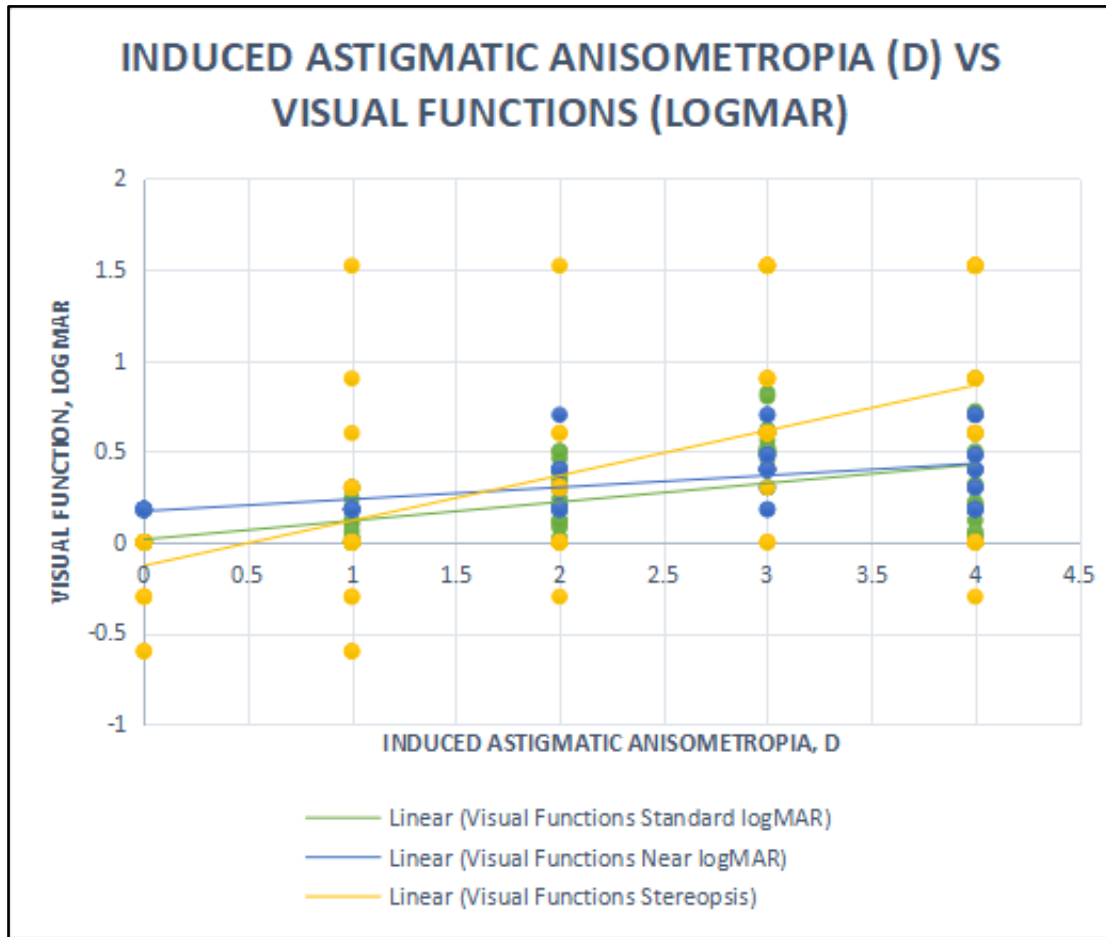


Figure 1. Graph shows the effect of induced astigmatic anisometropia on VA and stereopsis.

(B) Prediction of VA at distance, VA at near, and stereopsis by using simple linear regression

A simple linear regression was established that degree of induced astigmatic anisometropia could statistically significantly predict the VA at distance, VA at near and stereopsis. The least squares regression equations are:

I) Mean distance VA (logMAR) = 0.103 (cyl power) + 0.148

II) Mean near VA (logMAR) = 0.065 (cyl power) + 0.17

III) Mean stereopsis (logMAR) = 0.248 (cyl power) - 0.13

Table 1. Association between induced astigmatic anisometropia and VA at distance, VA at near, and stereopsis

	B-value	95% confidence interval	p-value
Distance VA	0.103	0.75, 0.131	<0.05
Near VA	0.065	0.048, 0.083	<0.05
Stereopsis	0.248	0.18, 0.316	<0.05

B-value shows the gradient of the slope in the graph (Figure 1). The higher the B-value, the higher the increment in logMAR value. Hence, this mean that the higher the B-value, the more the reduction in VA or stereopsis. Based on Table 1, the B-value of stereopsis is the highest as compared with VA at distance and VA at near. Therefore, stereopsis will reduce more in increment of astigmatic anisometropia.

DISCUSSION

Astigmatic anisometropia is one of the common caused for amblyopia (American Academy of Ophthalmology, 2014). It was reported that the prevalence of cylindrical anisometropia among preschool children in Middle East was 3.6% (Afsari et al., 2012). This situation need to be worried if it is not treated or being corrected, the degrading of stereopsis might affect their daily activities.

Induced astigmatic anisometropia affect stereopsis more than VA at distance and near and it is shown in Figure 1, where the slope of stereopsis is steeper as compared to slope of VA at distance and slope of VA at near. This happened due to binocularity involved. Gupta, et al. (2014) stated that the differences of image quality between right eye and left eye due to the anisometropia can cause incongruity between these two inputs and decrease in the level of binocular performances. The larger the differences in interocular aberration, the binocular visual performances will become more decreasing. This is due to the binocular summation takes into account spatial aspects, the maximum disparity related to stereopsis (Jimenez, et al., 2008). In addition, active suppression of inputs from one eye due to aniseikonia also prevents stereopsis and causes binocular performance to become worse than monocular viewing (South, et al., 2019).

Astigmatism always related to coma aberration (Hu, et al., 2004). Therefore, astigmatism also will cause the images formed become blurred and distorted. Astigmatism occurs when the tangential and sagittal images do not coincide. In the presence of astigmatism, the image of a point source is not a point, but takes the form of two separate lines. Between the astigmatic foci the image is an elliptical or circular blur (circle of least confusion). If the circle of least confusion fall on the retina, the image formed become less distorted rather than the sagittal focal point or tangential focal point (The Institute of Optics, 2003). Increasing the degrees of astigmatism will increase the distance of interval of Sturm and may cause the diameter of the circle of least confusion become larger (Optics of Human Eyes, 2011). The difference of astigmatism degrees between right eye and left eye will cause the difference of size and shape of images form on the retina (aniseikonia).

Meridional aniseikonia is one of the types of aniseikonia in which it affecting only one meridian compared to the corresponding meridian of the perceived image size in the other eye (South, et al., 2019). The uncorrected astigmatism in one eye will creates meridional aniseikonia and blurred image in one meridian on the retina disrupting normal visual pathway development for that eye and that particular meridian (Shetty, 2019). These meridional aniseikonia caused the two images perceived between right eye and left eye cannot be fused and binocularity is not achieved. Therefore, it caused the stereopsis affected more as compared to VA at distance and VA at near (Figure 1).

From this study, VA at distance and near, and also the stereopsis can be estimated by using the equation that come from the linear regression analysis. Therefore, the eyecare practitioner can predict the VA at distance, VA at near and stereopsis as it can be calculated by using these equation.

CONCLUSION

In conclusion, the increment of astigmatic anisometropia will degrades VA at distance and near, and stereopsis. However, stereopsis will much more affected as compared to VA at distance and VA at near in increasing degrees of astigmatic anisometropia.

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