Comparison of the Sphere, Cylinder, Spherical Equivalent and Cylindrical Axis Between the Left and Right Eyes

Sang-Deok Lee

Abstract: Background/Objectives: The objectives were to examine the difference in and relevance of the sphere, cylinder, cylindrical axis, and SE values between the left and right eyes.

Methods/Statistical analysis: The refraction function of KR-9000PW was used to measure the refractive errors of 382 eyes of 191 subjects. For the refractive errors measured, the distribution of the absolute differences between the L&R eyes was analyzed. In addition, correlation analyses were performed to find out the relevance of values between the L&Reyes. Findings: There were no significant differences in the mean values of the sphere, cylinder, cylindrical axis, and SE between the L&R eyes. Looking at the distribution of absolute difference of the refractive errors in the L&R eyes, over 50% of the subjects showed a difference smaller than 0.5D for the sphere, cylinder and SE. Over 80% of the subjects showed a difference smaller than 1D. On the contrary, a difference of 2D or larger was shown in 3.66% of the subjects for the sphere, 1.05% for the cylinder and 3.14% for the SE. The difference in the cylindrical axis was smaller than 20° in 66.05% of the subjects and between 70° and 90° in 8.09%. Also, all refractive errors analyzed showed a high correlation between the L&R eyes. Improvements/Applications: The results on the distribution and relevance of absolute difference of the refractive errors in the L&R eyes can be utilized as basic data for research on binocular vision including anisometropia.

Keywords: refractive error, sphere, cylinder, cylindrical axis,SE, anisometropia.

I. INTRODUCTION

The binocular visual function refers to a function in which images that come into the two eyes are clearly recognized as a single image by fusion. Formation of precise stereopsis the final step of binocular vision is associated with various elements of the eyes such as the refractive error, anisopia, suppression, heterophoria and amblyopia[1,2].

Anisometropia refers to the state in which the refractive error differs between the L&R(left and right) eyes. Aniseikonia means that size or shape of the retinal images formed on the two eyes is different. Aniseikonia is not a decisive cause of amblyopia or strabismus, but anisopia has been reported to be the primary cause of amblyopia that can inhibit the binocular visual function and cause strabismus[3-5].

Hyperopic anisometropia is known to occur more frequently and severely than myopic anisometropia.In addition, it has been reported that the frequency of amblyopia increases in the case of 2.00D for myopic anisometropia, 1.00D for hyperopic anisometropia and 1.50D for astigmatic anisometropia. When anisometropia is large, aniseikonia is induced after correcting with glasses. This results in inhibition of stereopsis and fusional vergence[6,7].

Even if a person has anisometropia, decreased visual acuity cannot be felt if vision of the eye with a low degree of the refractive error is fine, thus delaying the finding of anisometropia. However, since anisopia is a cause of amblyopia in children and a cause of asthenopia in adults, its finding is an important matter. There have been various studies on the binocular visual function such as anisopia, aniseikonia, amblyopia, strabismus and stereopsis, but more case studies are demanded[8-10].

This study aimed to examine the difference in and relevance of the sphere, cylinder, SE and cylindrical axis between the L&R eyes, and to provide basic data related to the study of binocular vision .

II. MATERIALS AND METHODS

This study was carried out on 191 subjects and 382 eyes including 112 male undergraduates and 79 female undergraduates who do not have history of eye diseases and ophthalmic surgeries. The mean age was 22 years, and the ages were distributed from 19 years to 26 years. One skilled inspector used the refraction function of KR-9000PW to measure the sphere, cylinder, cylindrical axis and SE of the eyes three times each, and the mean values were used.

Anisometropia was defined by absolute difference of the refractive errors between the L&R eyes, classified into the unit of 0.5D. When comparing the cylindrical axes, one of the axes was converted so that the difference in the values between the L&R eyes does not exceed 90°. SPSS 18.0 was used for statistical treatment.

III. RESULTS AND DISCUSSION

The mean values of the 191 subjects and 382 eyes were 6.28mm for pupil diameter, 6.29D for the sphere, -0.97D for the cylinder and -2.88 for the SE.The sphere, cylinder, cylindrical axis and SE of the right eye and left eye are presented in Table 1. The mean sphere of the right eye was -2.48D, which

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differed by 0.16D from -2.32D the mean value of the left eye. The cylinder values of the right eye and left eye were respectively -0.93D and -1.00D, showing a difference of 0.07D. The mean SE values were -2.94D for the right eye and -2.82D for the left eye, showing a difference of 0.12D. The cylindrical axes of the right eye and left eye were 131.92° and 128.66°, showing a difference of 3.26°. The difference in the sphere, cylinder, SE and cylindrical was extremely small, and there was no statistically significant difference in the mean values.

Table 1: The mean sphere, cylinder, cylindrical axis and SE values of the L&R eyes.

Refractive Errors	Right eye(Mean±SD)	Left eye(Mean±SD)
Sphere(D)	-2.48(±2.55)	-2.32(±2.50)
Cylinder(D)	-0.93(±1.08)	-1.00(±1.08)
SE(D)	-2.94(±2.72)	-2.82(±2.67)
Axis(°)	131.92(±68.76)	128.66(±70.47)

Figure 1 shows the distribution of the degree of absolute anisometropia for the 191 subjects. Based on the comparison of the sphere between the L&R eyes, 97 subjects or 50.79% showed a value below 0.50D and 60 subjects or 31.41% showed a value between 0.50D and 1.00D. This means that in 82.2% of the subjects, the difference in the sphere was smaller than 1.00D. For the remaining subjects, 27 subjects or 14.14% had a value between 1.00D and 2.00D, and 7 subjects or 3.66% had a value of 2.00D or above.

As for the cylinder, 54.45% (104 subjects) showed anisometropia below 0.50D and 34.55% (66 subjects) had a value between 0.50D and 1.00D. The ratio of these two cases was 89.00% of all subjects. A value between 1.00D and 2.00D was shown by 9.95% (19 subjects) and a value of 2.00D or above was shown by 1.05% (2 subjects)[Figure 2].

In the case of SE, which is a combination of the sphere and cylinder, 113 subjects or 59.16% showed a difference smaller than 0.50D between the L&R eyes and 46 subjects or 24.09% had a value between 0.50D and 1.00D. Similar to the sphere and cylinder, most subjects (83.25%) showed a difference smaller than 1.00D. A value between 1.00D and 2.00D was shown by 26 subjects or 13.61%. The ratio of subjects who showed a difference larger than 2.00D which can lead to aniseikonia caused by anisometropia was 3.14% (6 subjects)[Figure 3].

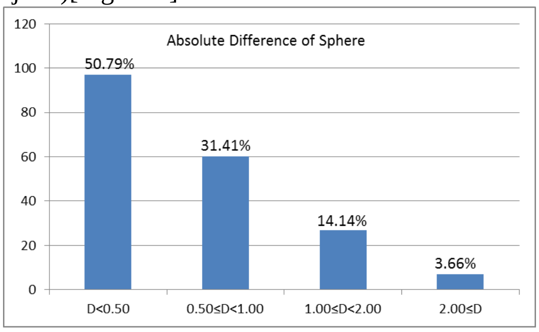

Figure 1. The distribution of absolute difference of the sphere values for the L&R eyes

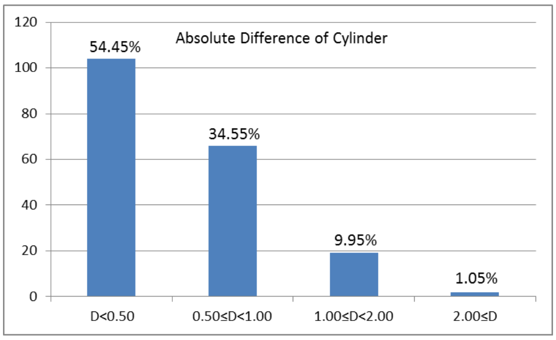

Figure 2. The distribution of absolute difference of the cylinder values for the L&R eyes

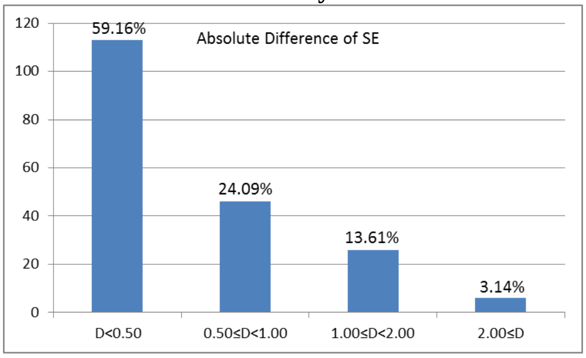

Figure 3. The distribution of absolute difference of the SE values for the L&R eyes

The distribution of the absolute difference in the cylindrical axis between L&R eyes, at a 5° interval for values below 30° and at a 10° interval for 30° or above[Figure 4]. The difference in the axis was smaller than 5° in 50 subjects or 26.18%, between 5° and 10° in 38 subjects or 19.90%, between 10° and 15° in 21 subjects or 10.99%, and between 15° and 20° in 18 subjects or 9.42%. Out of the 191 subjects, 127 subjects or 66.50% had a difference smaller than 20° in the axis. The cases in which the difference in the axis between the L&R eyes was between 70° and 90°, nearly vertical, were found in 17 subjects or 8.90%.

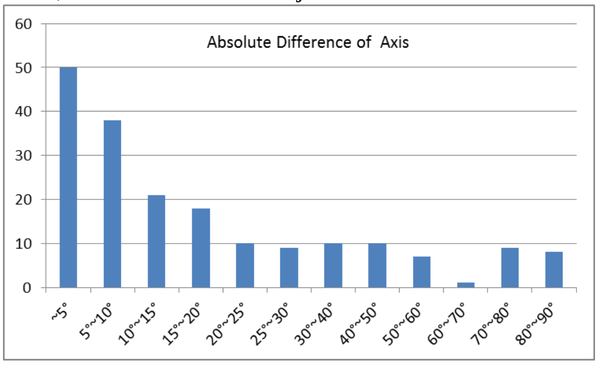

Figure 4. The distribution of the absolute difference in the cylindrical axis between the L&R eyes

The correlation of the sphere, cylinder, cylindrical axis and SE values was examined. All of the analyzed values showed a high correlation between the L&R eyes. Increasing refractive errors of the right eye increased the values of the left eye. The correlation coefficient between L&R eyes was 0.919 for the sphere, 0.829 for the cylinder and 0.934 for the SE. The correlation coefficient of the cylindrical axes was 0.898. [Figure 5 and 6].

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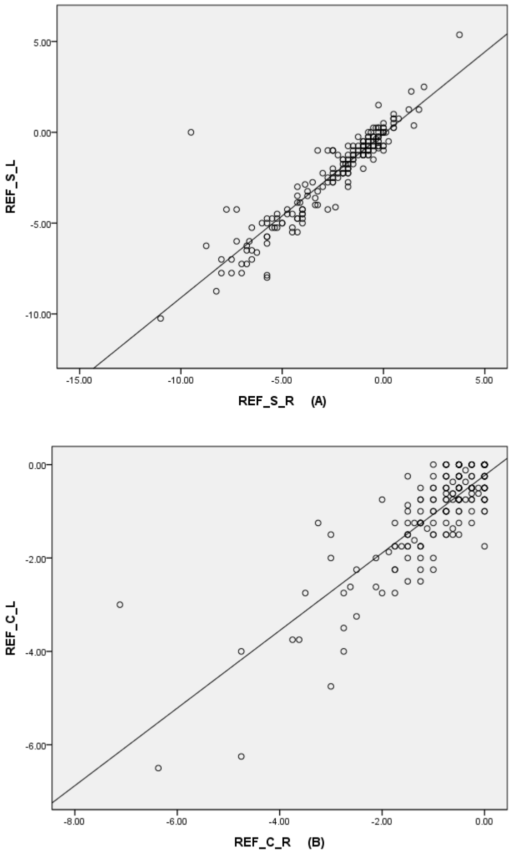

Figure 5.The correlation of the sphere and cylinder values between the L&R eyes.

(A) : Sphere values between the L&R eyes(r=0.919, p=0.000)

(B) : Cylindervalues between the L&R eyes(r=0.829, p=0.000)

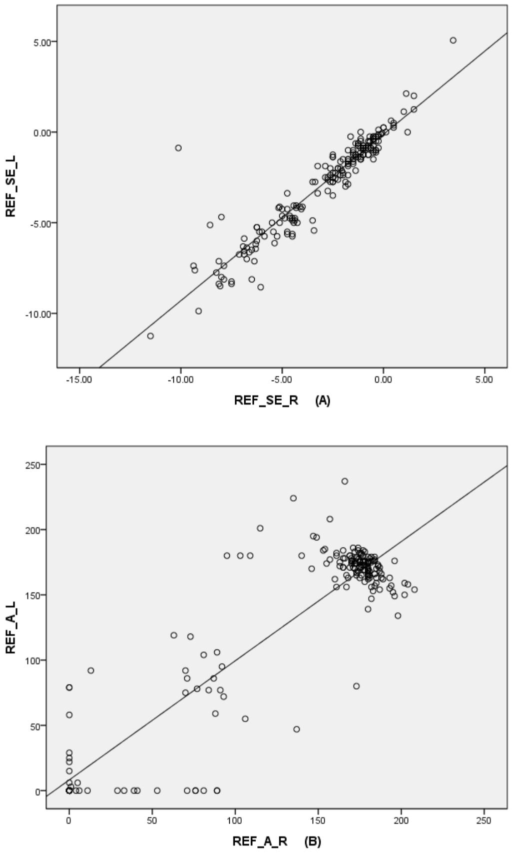

Figure 6.The correlation of the SEand cylindrical axisvalues between the L&R eyes.

(A) : SEvalues between the L&R eyes(r=0.934, p=0.000)

(B) : Axisvalues between the L&R eyes(r=0.898, p=0.000)

IV. CONCLUSION

Based on the comparison of the difference in the sphere, cylinder and SE between the L&R eyes, the ratio of subjects who showed a difference smaller than 1D was 82.20% for the sphere, 89.00% for the cylinder and 83.25% for the SE. The cases that showed a difference of 2D or larger, which can lead to aniseikonia caused by anisometropia, were found in 3.66% of the subjects for the sphere, 1.05% for the cylinder and 3.14% for the SE.

The ratio of subjects who had a difference smaller than 5° in the cylindrical axis between the L&R eyes was highest at 26.18%. The distribution ratio decreased with increasing difference in the axis, and a value between 70° and 90°, nearly vertical, was found in 8.90%.

A high correlation was shown by the sphere, cylinder, cylindrical axis and SE values between the L&R eyes, and increasing refractive errors of the right eye led to an increase in the values of the left eye.

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