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The Incidence of Congenital Color Deficiency among Koreans

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It is important to investigate the incidence of congenital color deficiency and to determine the type and degree because the color deficiency can effect as a handicap to certain occupations. The incidence of congenital color deficiency is remarkably constant among Caucasians but other races show considerable variations. We investigated the incidence of congenital color deficiency among Koreans by the use of H-R-R pseudoisochromatic plates. The present study revealed that the incidence of congenital color deficiency among Koreans was 3.15% (5.90% in men, 0.44% in women).

Key Words: *Color deficiency*

INTRODUCTION

The stimuli for color vision are light rays reflected from an object. This appearance depends on their intensity and on the surrounding colors. The rays are not colored, but those light rays that have a wavelength between 400nm and 700nm stimulate retinal cones so that colors are perceived. Thomas Young (1801) postulated the trichromatic theory that three principal classes of retinal cones are responsible for color vision. Three cones have a peak sensitivity in the region of 570nm (red sensitive cones), 535nm (green sensitive cones) and 440nm (blue sensitive cones). On the basis of trichromatic theory, one might predict that congenital color deficiency would involve the abnormality or absence of one or more cone pigments (Newell, 1986).

Nowadays, color deficiency can effect as a handicap to certain occupations. Therefore it is important to investigate the incidence of color deficiency and to be able to determine the type and degree of a subject's color deficiency in order to judge whether this deficiency constitute a real handicap in his daily life and in the performance of his chosen work.

Color deficiency may be acquired or congenital. Acquired color deficiency is the result of systemic or ocular diseases such as macular, panretinal and optic nerve diseases. The common congenital type of color deficiency is inherited as X-linked characteristics. Both types may have similar test results but a congenital deficiency never show a progression of symptoms or any fundus changes.

The incidence of these color deficiencies is remarkably constant among Caucasian, however, reported data on the other races show considerable variation. But up to now, there have been no data about the congenital color deficiency among Koreans. In the present study, the authors investigated the incidence of congenital color deficiency among Koreans by use of H-R-R pseudoisochromatic plates.

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MATERIALS AND METHODS

The total number of study subjects in this study were 9,438 persons consisting of 4,678 men and 4,760

women from October 1987 through November 1988. All subjects were 3rd grade students of middle school. The number of middle schools included in this study was 14, 10 in Seoul and 4 in Daejeon, which were selected randomly. The congenital color deficient cases were identified by 10 residents of ophthalmology who were educated the test methods. None of the subjects showed pathologic findings in the fundus with a direct ophthalmoscope.

The screening for congenital color deficiency was perfomed with Hardy-Rand-Rittler (H-R-R) pseudoisochromatic plates. The results were classified under the guidance of instructions in the test plates. Depending on the type, congenital color deficiency was classified into red-green and blue-yellow deficiency. Red-green deficiency was also classified into protan, deutan and unclassified, and blue-yellow deficiency was classified into tritan, tetartan and unclassified. Depending on the quantitative degree, congenital color deficiency was classified into mild, medium and strong.

RESULTS

The incidence of congenital color deficiency (Table 1): *Among the 9,438 subjects, 297 were identified to be the congenital color deficient persons (3.15%). All of them showed red-green color deficiency. There were significant differences in the incidence between men (5.90%) and women (0.44%).*

Table 1. The incidence of congenital color deficiency

Sex	Subjects	No. of Color deficient person	%
Men	4678	276	5.90
Women	4760	21	0.44
Total	9438	297	3.15
			p<0.001

Table 2. Classification of congenital color deficiency according to type

Type	Number		
	Men No. (%)	Women No. (%)	Total No. (%)
Protan	80 (29.0%)	3 (14.3%)	83 (27.9%)
Deutan	150 (54.3%)	8 (38.1%)	158 (53.2%)
Unclassified	46 (16.7%)	10 (47.6%)	56 (18.9%)
Total	276 (100%)	21 (100%)	297 (100%)

Distribution of congenital color deficiency according to the type (Table 2): *Protan, deutan and unclassified type comprises 27.9%, 53.2% and 18.9%, respectively, among the red-green color deficient persons.*

Distribution of congenital color deficiency according to the degree (Table 3): *Mild, medium and strong degree comprises 35.0%, 33.7% and 31.3%, respectively, among the red-green color deficient persons.*

Table 3. Classification of congenital color deficiency according to degree

Degree	Number of subjects		
	Men No. (%)	Women No. (%)	Total No. (%)
Mild	90 (32.6%)	14 (66.7%)	104 (35.0)
Medium	96 (34.8%)	4 (19.0%)	100 (33.7%)
Strong	90 (32.6%)	3 (14.3%)	93 (31.3%)
Total	276 (100%)	21 (100%)	297 (100%)

DISCUSSION

Congenital color deficiency can be classified according to the degree and spectral location of pigments involved. Depending on the degree, color deficiencies are classified to anomalous trichromacy, in which the affected individual has three cone pigments but one of them is abnormal, and dichromats, in which the affected individual has only two pigments (Peyman et al.). But it is difficult to differentiate the anomalous trichromacy and dichromats clinically. So Hardy et al (1950) classified the degree quantitatively into mild, and strong. In addition, monochromatism or achromatopsia refers to individuals who have only a single cone pigment, or who lack cone pigments altogether (rod monochromatism). Rod monochromats can distinguish colored objects only in terms of brightness. According to the type of spectral location, color deficiencies are classified to protan (abnormal red sensitive cones), deutan (abnormal green sensitive cones) and tritan (abnormal blue sensitive cones).

There are several methods of clinical tests for color vision, such as anomaloscope, panel tests (Farnworth-Munsell 100 hue test, Farnworth D-15 test) and pseudoisochromatic plates.

The anomaloscope is an accurate technique which was first designed for clinical use in 1907 (Dreyer, 1969). This test is based upon a matching of a mixture of red light of 670nm wavelength with green light

of 546nm wave length with a standard yellow color of 589nm wavelength. Normal viewers and individuals with red-green deficiency use characteristic proportions of red and green to match the yellow. On the one side of test results, one can group color deficiency in the subtypes protans and deutans, and on the other side, a classification of anomalous trichromacy and dichromats can be made (Dreyer, 1969). Gunkel (1981) considered the Nagel anomaloscope as the instrument of choice for evaluating red-green deficiency.

Despite its high sensitivity, the Nagel anomaloscope is not adequate for the screening of color deficiency, because it costs much and necessitates considerable ability in handling (Kim and Kwon, 1985).

The panel tests (100 hue, D-15) are relatively accurate in classifying color deficiency because the subject's errors can be plotted to define an axis of color deficiency. The 100 hue test actually consists of 85 colored tablets that are designed to approximate the minimum difference between hues that a normal observer can distinguish (1 to 4nm). A normal observer arranges the tablets in sequence with few errors, but a color deficient subject has trouble with those parts of the spectrum complementary to the subject's deficiency. This test is very sensitive for subtle deficiencies but suffers because a long time is required to perform the test and to analyze the results. The D-15 test is more rapid and convenient test for clinical use because it consists of only a single box of 15 colored tablets. But the D-15 test is not sensitive and will miss mildly affected individuals (Peyman et al., 1980).

More simple but less accurate tests can be widely employed in clinics, the most popular of which are pseudoisochromatic plates such as Ishihara and Hard-Rand-Rittler (H-R-R) plates. The pseudoisochromatic plates depict colored numbers or figures that stand out from a background of dots. Individuals with color deficiency will either see no pattern at all or an alternative pattern. Both tests can detect the great majority of those with red-green color deficiency. Each of these tests, however, fails occasionally to detect mild degrees of red-green deficiency. Crone (1961) reported that the Ishihara plates were excellent for differentiation between normals and abnormals but were unsuitable for quantitative differentiation. The H-R-R plates, on the contrary, were unsuitable for differentiating between normals and abnormals but were very good for quantitative differentiation and for distinguishing between protan and deutan types. Even though the pseudoisochromatic plate tests have many shortcomings, they are quick to perform and sensitive for screening color deficient persons. In the present study, we used H-R-R pseudoisochromatic plates as a test device for identification and classification of congenital color deficiency.

The incidence of congenital color deficiency is remarkably constant among Caucasian (8.2%, Duke-Elder, 1986), but reported data on the other races show considerable variation. The level of incidence is about half of that of Caucasian in American Negroes (3.71%, Clement, 1930), Japanese (3.9%, Sato, 1935) and Chinese (Chan and Mao, 1950). Color deficiency is less common among natives of the Congo (1.7%, Applemans et al., 1953) and Uganda (1.86%, Simon, 1951). Mann and Turner (1956) stated that this variation among primitive people has been explained ecologically since it could be argued that color deficient members of a tribe that fail to distinguish red from green in poisonous fruit will be eradicated as a result of this deficiency.

In the distibution of color deficiency, by type and degree, Hardy et al. (1954) reported through the use of H-R-R pseudoisochromatic plates that protan, deutan and unclassified types comprised 37.3%, 59.3% and 3.3% respectively, and mild, medium and strong degree comprised 22.8%, 29.8% and 47.4% respectively. With the use of the Nagel anomaloscope, Kim and Kwon (1985) reported that protan and deutan comprised 26.4% and 73.6%, and anomalous trichromacy and dichromats comprised 50.1% and 49.1% of color deficient subjects tested.

In the present study, the incidence of color deficiency was estimated to be 3.15%, in which the men and women incidences were 5.90% and 0.44% respectively. They were all red-green color deficient persons. No one showed blue-yellow color deficiency or monochromatism. Duke-Elder (1968) reported that the incidence of blue-yellow color deficiency is extremely rare (0.0001%). Therefore, for the screening of blue-yellow color deficiency, a considerably larger size of subjects will be needed. Protan, deutan and unclassified types were 27.9%, 53.2% and 18.9% respectively and mild, medium and strong degrees were exhibited in 35.0%, 33.7% and 31.3% respectively of color deficient subjects. We could not suggest the statistical significance between the differences in men and women according to type and degree because of the small sample size in women.

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