

# Changes in Macular Pigment Optical Density and Visual Acuity after Lutein Supplementation in Adults in Their 20s

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**Purpose:** This study was conducted to determine whether lutein supplementation (including zeaxanthin) improves macular pigment optical density (MPOD) and visual acuity. **Methods:** One hundred and twenty adults in their 20s (60 subjects in the experimental group that received lutein, 60 subjects in the control group) who had no systemic diseases or specific eye diseases (macular pigment degeneration and cataract) were included and allocated to experimental and control groups. The experimental and control groups were administered with 20 mg lutein (which naturally contains 1.5 mg zeaxanthin) and soybean oil in pill form, respectively, once a day for 6 months. MPOD was measured with a Macular Pigment Screener II (MPS II ®) every month, while distance and near visual acuities, refractive error (S.E), and contrast sensitivity were measured before and after 6 months of the supplementation. **Results:** The MPOD in the control group did not improve after 6 months (baseline 0.64±0.10 to study end 0.63±0.13) in both eyes; the experimental group showed a statistically significant improvement from 0.62±0.11 before to 0.68±0.12 after the 6 months of supplementation ( $p=0.000$ ,  $t=4.554$ ). Subjects with high or low myopia in the experimental group also showed a statistically significant improvement in MPOD (right eye: high degree [ $p=0.029$ ,  $t=2.435$ ], low degree [ $p=0.000$ ,  $t=4.160$ ]; left eye: high degree [ $p=0.014$ ,  $t=2.810$ ], low degree [ $p=0.041$ ,  $t=2.177$ ]), while those with moderate myopia in the same group showed no significant change (right eye:  $p>0.05$ ,  $t=0.569$ ; left eye:  $p>0.05$ ,  $t=0.535$ ). The near visual acuities for both eyes in the experimental group significantly improved after the supplementation ( $p=0.001$ ,  $t=3.419$ ). Contrast sensitivity at most frequencies also improved for the right eye, left eye, and both eyes; there was no significant improvement in the right eye in the experimental group at high frequencies, and a decline was observed for all the frequencies in the right eye, left eye, and both eyes in the control group. **Conclusions:** Lutein supplementation for 6 months improves MPOD, myopia, near visual acuity, and contrast sensitivity at selected frequencies.

**Keywords:** Macular pigment optical density, Lutein, Zeaxanthin, Contrast sensitivity

## Introduction

There is a spot called macula in the retina of our eyes. The nerve tissue located in this center of the retina plays a crucial role in our ability to see objects. Since it is where visual cells are concentrated most and images are formed, it is not too much to say that the health of macula determines the eyesight. It is known that the center of the macula consists of a substance called zeaxanthin and the periphery consists of lutein.

Lutein is a carotenoid with strong antioxidant activity and is absorbing blue light. Lutein is found in high quantities in green and yellow vegetables such as spinach, green

bean, and broccoli.<sup>[1]</sup> Lutein and zeaxanthin in the vegetables or supplements are reported to help protect eyes from exposure to blue light in primates and human adults.<sup>[2,3]</sup> They do so by absorbing blue light and by acting as a filter that reduces the photochemistry damage by high energy blue light in the retina and are reported to act as an antioxidant that prevents the oxidative damage of retina by the harmful light.<sup>[4,5]</sup> Although there has been no data on the influence of supplements such as lutein on the eyesight of children, some studies showed that they are beneficial for adult patients with visual function problems, like Age Related Macular Degeneration.<sup>[6,7]</sup> As reported from the studies above, lutein and zeaxanthin can only be obtained from food such

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as green and yellow vegetables or supplements because they are not synthesized in the human body.<sup>[8]</sup> The substances are also getting more attention in other fields than eye health, as a recent study suggested their influence on skin health<sup>[9]</sup> and brain health.<sup>[10]</sup> Researchers including Hammond BR published studies on the effects of lutein on macular pigment optical density (MPOD).<sup>[11]</sup> In Korea, related studies have mainly focused on health impact assessment,<sup>[12]</sup> health functional food recognition,<sup>[13]</sup> substance extraction condition,<sup>[14]</sup> and eye health care,<sup>[15]</sup> and there has been hardly any studies on the direct effects on eyes.

According to the Korea National Health Statistics in 2012, the animal-based food consumption has been on the rise from below 10% in the mid-1970s to above 20% in the 1990s and reached 20.6% in 2012 whereas the plant-based food consumption has decreased.<sup>[16]</sup> As the statistics suggest, Koreans in their 20s have very low consumption levels of green and yellow vegetables as the diets have been westernized. By that, less lutein is consumed by vegetables which leads to a less dense macular pigment. On the other side, the younger generation is much more exposed to blue light due to usage of digital devices including smartphones or in-house lightening by LEDs. Therefore, this study was conducted to investigate if lutein supplementation has a beneficial impact on MPOD and on visual functions in Koreans.

## Subject and Method

### 1. Subject

This study was conducted on 120 adults (60 subjects in the experimental group, 60 subjects in the control group) without any systemic diseases or particular eye diseases (macular pigment degeneration and cataract) who understood the contents and agreed to participate.

### 2. Supplementation Contents and Method

#### 1) Amount and method

The experimental group received a dietary supplement containing lutein and zeaxanthin in the ratio of 20 mg : 1.5 mg in pill form (hereinafter referred to lutein) once a day. The 1.5 mg zeaxanthin is naturally present in the lutein powder.

The control group received a pill containing soybean oil (hereinafter referred to control food) once a day.

### 2) Period

The study participants took either lutein (test food) or the control food once a day for 6 months from June 2019 to November 2019.

### 3) Subject assignment

This study was a double-blind study. This setup prevents that neither the researchers nor the study participants know in which intervention group (experimental group or control) the study participant was.

## 3. Test Method

### 1) Examination

Basic information on the subjects was collected, which included the presence of systemic diseases or eye diseases, history of eye surgery, medication, and vision correction method.

### 2) MPOD distribution

Using a macular pigment screener II (MPS II ®; Elektron Eye Technology, Cambridge, UK, K clarity Inc. in Korea), macular pigment optical density (MPOD) was measured in both eyes in the experimental group once a month for 6 months and in the control group only at the beginning and the end of the 6 months intervention period.

The MPS II is a computerized device designed for measuring MPOD and used to identify patients at the risk for the early development of AMD.<sup>[16]</sup> The device measures the attenuation of blue light by macular pigments in density units (DU) in the range from 0 to 1. Heterochromatic flicker photometry (HFP) is used as the measurement method, and the background brightness is set at 250 cdm<sup>-2</sup> to lower the impact on rod cells and cone cells including s-cones in particular. A researcher initiates the measurement with a noninvasive, low intensity light that does not require pupil dilation by pushing the start button when a subject is looking at the blinking light. The technique uses the property of macular pigment, which is to absorb the spectrum of lights ranged from blue to green (460 nm-570 nm). MPOD is determined during the process of alternating the lights which macular pigment are known to absorb at fovea centralis and periphery that the macular pigment and adjusting the lights' relative intensities until the sensation of flicker is minimized or disappeared. This is based on the assumption that macular pigment density is at its maxi-



Fig. 1. MPS II ©. (Elektron Eye Technology, Cambridge, UK)

imum at the fovea centralis, and it decreases exponentially at 6 to 8 degrees eccentricity to the minimum or zero. The measurements are given by  $\log [MPOD = \text{Log } 10(Bf/Bp)]$ , which represents the comparison between the light intensities needed at the center (Bf) and periphery (Bp).<sup>[18]</sup>

### 3) Distance visual acuity

The examination room intensity of illumination was conducted about 200 lux. Because, Woo and Long mention that 800 to 1,000 lux of illumination on the vision chart and 130 to 215 lux around the vision chart were appropriate.<sup>[19]</sup>

Using the Randolt ring in the distance vision chart for 5 meters (Hubitz HDC-9000), the distance visual acuity was measured individually on each eye of subjects in the experimental group before (the beginning of study) and after lutein supplementation (after 6 months). The same was performed on subjects in the control group with the supplementation of control food.

### 4) Near visual acuity

The examination room intensity of illumination was conducted about 200 lux. Because, Woo and Long mention that 800 to 1,000 lux of illumination on the vision chart and 130 to 215 lux around the vision chart were appropriate.<sup>[19]</sup>

Using the Randolt ring in the near vision chart for 40 cm (Hubitz near vision chart), the distance visual acuity was measured individually on each eye, of subjects in the experimental group before (the beginning of study) and after lutein supplementation (after 6 months). The same was performed on subjects in the control group with the supplementation of control food.

### 5) Refraction

Using an objective auto-refractometer (NIDEK ARK-1A, Figure 2), the refraction was measured individually on each eye, of subjects in the experimental group before and after lutein supplementation (after 6 months). The same was performed on subjects in the control group with the supplementation of control food.

### 6) Contrast sensitivity

Using the distance contrast sensitivity chart (Vector Vision CSV-1000E, Figure 2), the contrast sensitivity was measured individually on each eye of subjects in the experimental group before and after lutein supplementation (after 6 months) under full correction. The same was performed on subjects in the control group with the supplementation of control food.

The distance contrast sensitivity chart is a contrast sensitivity chart with a striped pattern. The striped pattern has 3, 6, 12, 18 cycles/degree (cpd) with the spatial frequency increasing towards the bottom and the contrast sensitivity decreasing towards the right. The cpd unit represents the number of stripes per degree.

### 4. Statistics

Statistics was only done one the PP (per protocol) population. This is the group of people who took the supplements every day and completed all tests and thus were fully compliant with the study procedures described in the protocol.

Paired t-test in SPSS (25.0 ver) was used to identify the difference in distance and near visual acuity, contrast sensitivity, and MPOD between the experimental group and

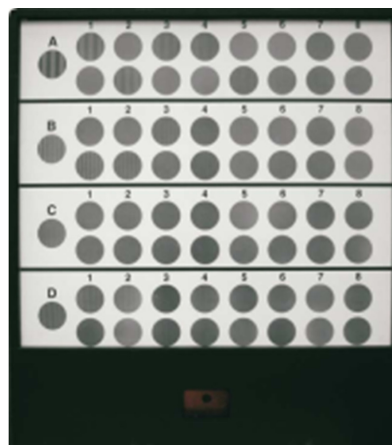


Fig. 2. Vector Vision. CSV-1000E chart. (USA)

Table 1. Characteristics of intention to the experimental group set at baseline and after 6 months

	Control				Experimental			
	N=60				N=60			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Gender M/F	27/33				35/25			
Age, y	22.8	2.66	20.00	30.00	23.35	2.71	20.00	30.00
1st OD_SE	-3.12	2.48	-10.38	0.13	-3.79	2.64	-11.75	0.13
2nd OD_SE	-3.20	2.59	-10.00	0.38	-3.80	2.90	-14.63	0.13
1st OS_SE	-3.08	2.63	-11.00	0.38	-3.72	2.65	-10.50	0.13
2nd OS_SE	-3.10	2.65	-9.75	0.63	-3.73	2.77	-11.38	0.88
1st OU VA, far	0.54	0.52	0.01	1.50	0.41	0.50	0.01	1.50
2nd OU VA, far	0.53	0.53	0.02	1.50	0.41	0.47	0.03	1.50
1st OD VA, far	0.42	0.44	0.01	1.20	0.30	0.39	0.01	1.50
2nd OD VA, far	0.42	0.45	0.02	1.50	0.32	0.39	0.03	1.50
1st OS VA, far	0.42	0.45	0.01	1.50	0.32	0.41	0.01	1.20
2nd OS VA, far	0.46	0.48	0.02	1.50	0.32	0.40	0.02	1.50
1st OU VA, near	0.57	0.39	0.05	1.00	0.47	0.38	0.05	1.00
2nd OU VA, near	0.61	0.40	0.07	1.00	0.55	0.40	0.07	1.00
1st OD VA, near	0.50	0.37	0.05	1.00	0.43	0.38	0.03	1.00
2nd OD VA, near	0.53	0.41	0.06	1.00	0.44	0.38	0.05	1.00
1st OS VA, near	0.51	0.39	0.05	1.00	0.42	0.36	0.03	1.00
2nd OS VA, near	0.53	0.38	0.06	1.00	0.47	0.37	0.06	1.00
1st Contrast OU, 3 SF	5.87	0.93	4.00	8.00	5.72	0.85	4.00	8.00
1st Contrast OU, 6 SF	5.23	1.32	1.00	8.00	5.05	1.22	2.00	8.00
1st Contrast OU, 12 SF	4.40	1.71	0.00	8.00	4.05	1.72	1.00	8.00
1st Contrast OU, 18 SF	4.52	1.89	0.00	8.00	3.97	1.79	0.00	8.00
2nd Contrast OU, 3 SF	5.70	1.05	4.00	8.00	5.82	1.11	4.00	8.00
2nd Contrast OU, 6 SF	4.90	1.45	1.00	8.00	5.07	1.48	2.00	8.00
2nd Contrast OU, 12 SF	4.13	1.80	0.00	8.00	4.17	1.91	0.00	8.00
2nd Contrast OU, 18 SF	4.10	1.87	0.00	8.00	4.02	2.17	0.00	8.00
1st Contrast OD, 3 SF	5.23	1.06	3.00	8.00	5.07	1.01	3.00	8.00
1st Contrast OD, 6 SF	4.52	1.42	0.00	8.00	4.00	1.47	0.00	6.00
1st Contrast OD, 12 SF	3.55	1.75	0.00	8.00	3.03	1.73	0.00	8.00
1st Contrast OD, 18 SF	3.57	1.78	0.00	8.00	2.95	1.99	0.00	7.00
2nd Contrast OD, 3 SF	4.85	1.22	1.00	8.00	4.78	1.37	0.00	7.00
2nd Contrast OD, 6 SF	4.08	1.59	0.00	8.00	4.15	1.47	0.00	8.00
2nd Contrast OD, 12 SF	3.12	2.13	0.00	8.00	2.78	1.81	0.00	7.00
2nd Contrast OD, 18 SF	3.02	1.98	0.00	8.00	2.88	1.75	0.00	8.00
1st Contrast OS, 3 SF	5.18	1.03	2.00	7.00	5.00	0.91	3.00	7.00
1st Contrast OS, 6 SF	4.35	1.62	0.00	8.00	4.25	1.49	1.00	7.00
1st Contrast OS, 12 SF	3.63	2.03	0.00	8.00	3.17	1.78	0.00	7.00
1st Contrast OS, 18 SF	3.52	1.94	0.00	8.00	3.12	1.92	0.00	7.00
2nd Contrast OS, 3 SF	5.05	1.28	2.00	7.00	5.20	1.18	3.00	8.00
2nd Contrast OS, 6 SF	4.33	1.53	1.00	8.00	4.30	1.75	0.00	8.00
2nd Contrast OS, 12 SF	3.35	2.10	0.00	8.00	3.42	2.17	0.00	8.00
2nd Contrast OS, 18 SF	3.12	2.04	0.00	8.00	3.32	2.07	0.00	8.00
1st MPOD OU (avg)	0.64	0.10	0.24	0.81	0.62	0.11	0.41	0.86
2nd MPOD OU (avg)	0.63	0.13	0.36	0.98	0.68	0.12	0.36	0.98
1st MPOD OD	0.63	0.12	0.34	0.90	0.63	0.12	0.38	0.86
2nd MPOD OD	0.62	0.15	0.24	0.99	0.69	0.14	0.38	0.99
1st MPOD OS	0.64	0.11	0.14	0.91	0.61	0.14	0.29	0.91
2nd MPOD OS	0.65	0.14	0.34	0.99	0.68	0.12	0.24	0.99

OD = oculus dexter, OS = oculus sinister, OU = oculus uterque, SE = spherical equivalent, MPOD = macular pigment optical density, SF = Spatial frequency.

the control group, and test results were considered statistically significant when the significance level is less than 0.05.

## Result and Discussion

### 1. Changes in MPOD in both eyes

The control group of 60 subjects consisted of 27 men and 33 women, and the experimental group of 60 subjects consisted of 35 men and 25 women. The average age was  $22.8 \pm 2.66$  in the control group and  $23.35 \pm 2.71$  in the experimental group (Table 1).

The control group showed a slight decrease in MPOD from  $0.64 \pm 0.10$  before the supplementation of control food and  $0.63 \pm 0.13$  after the 6 months supplementation. On the other hand, the experimental lutein group showed a statistically significant increase by about 0.06 in MPOD from  $0.62 \pm 0.11$  before the supplementation of lutein and  $0.68 \pm 0.12$  after the supplementation. The difference between the MPOD results in both eyes before and after the supplementation was higher in the experimental group, which was also statistically significant ( $p=0.000$ ,  $t=4.554$ ) (Table 2 & Fig. 3). Preceding studies, including one by Hammond, demonstrated that the 6 months of lutein supplementation increased MPOD by about 0.05, as also shown in this study, and reported a significant increase in MPOD in the areas 10, 30, 60, and 105 minutes away from the fovea

Table 2. Comparison between macular pigment optical densities of the experimental and control groups after 6 months

	Mean	±SD	t	df	p
Control (N=60)	0.00	0.13	-0.191	59	0.849
Experimental (N=60)	0.06	0.10	4.554	59	0.000

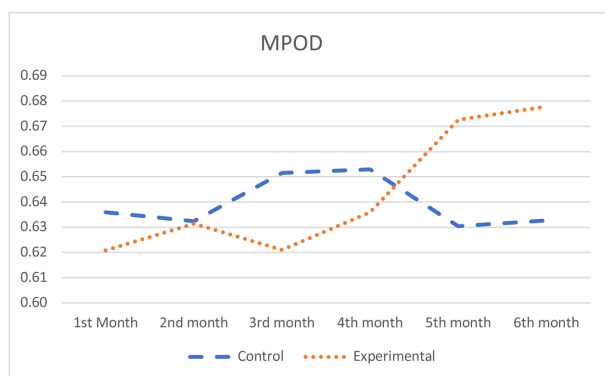


Fig. 3. Significant increase in macular pigment optical density in the experimental group compared to the control group.

centralis in the experimental group supplemented with lutein 10 mg and zeaxanthin 2 mg for 1 year when compared to a control group. Also, the experimental lutein group showed a significant improvement in contrast sensitivity as well as recovery time from light stress.<sup>[11]</sup> Many preceding studies, including ones by Stringham and Hammond, have reported that the experimental group supplemented with lutein and zeaxanthin showed improvement in MPOD.<sup>[20-26]</sup>

In addition, the significant improvement of MPOD was seen in both genders, when comparing the genders in the control and the experimental group ( $p=0.005$  in men,  $p=0.001$  in women, Table 3).

### 2. Changes in MPOD according to the degree of myopia with refractive errors

The spherical equivalent was calculated to determine the degree of refractive error. Efron<sup>[27]</sup> classified the progression of myopia into three degrees: low degree (0.00 ~ -2.75 D), moderate degree (-3.00 ~ -5.00 D), and high degree (< -5.00 D). This study also measured the changes in MPOD in the right and left eyes according to each degree of myopia in the control group and the experimental group.

#### 1) Changes in MPOD in the right eye

In the right eye, subjects with high degree myopia in the control group showed a decrease in MPOD from  $0.65 \pm 0.12$  before the supplementation to  $0.58 \pm 0.17$  after 6 months of the control supplementation while those in the experimental lutein group showed a statistically significant increase from  $0.65 \pm 0.13$  before the supplementation to  $0.73 \pm 0.12$  after 6 months ( $p=0.029$ ,  $t=2.435$ ).

Subjects with moderate degree myopia in the control group showed a decrease in MPOD in the right eye from  $0.67 \pm 0.10$  before the supplementation to  $0.65 \pm 0.14$  after 6 months of the supplementation while those in the experimental group showed an increase from  $0.65 \pm 0.15$  before the supplementation of lutein to  $0.63 \pm 0.14$  after 6 months,

Table 3. Comparison between macular pigment optical densities of male and female subjects

		Mean	±SD	t	df	p
Control	Male	0.00	0.15	-0.113	26	0.911
	Female	0.00	0.12	-0.157	32	0.876
Experimental	Male	0.06	0.11	2.970	34	0.005
	Female	0.07	0.09	3.684	24	0.001

Table 4. Myopia classified as low, moderate, and high in the control group

		Mean	±SD	t	df	p
OD	Low myopia	0.02	0.18	0.588	26	0.562
	Moderate myopia	-0.01	0.16	-0.347	14	0.734
	High myopia	-0.07	0.18	-1.572	14	0.138
OS	Low myopia	-0.02	0.13	-0.724	26	0.476
	Moderate myopia	0.07	0.13	1.681	10	0.124
	High myopia	-0.02	0.19	-0.375	16	0.712

Table 5. Myopia classified as low, moderate, and high in the experimental group

		Mean	±SD	t	df	p
OD	Low myopia	0.09	0.09	4.160	20	0.000
	Moderate myopia	0.02	0.14	0.569	22	0.575
	High myopia	0.07	0.12	2.435	14	0.029
OS	Low myopia	0.06	0.13	2.177	21	0.041
	Moderate myopia	0.02	0.17	0.535	20	0.598
	High myopia	0.10	0.14	2.810	14	0.014

however without a statistically significant difference ( $p > 0.05$ ,  $t = 0.569$ ).

Subjects with low degree myopia in the control group showed a slight increase in MPOD in the right eye from  $0.59 \pm 0.11$  before the supplementation to  $0.61 \pm 0.16$  after 6 months of the supplementation while those in the experimental group showed a statistically significant increase from  $0.61 \pm 0.08$  before the supplementation to  $0.69 \pm 0.11$  after 6 months after the supplementation ( $p = 0.000$ ,  $t = 4.160$ ) (Table 4, Table 5 & Fig. 4).

## 2) Changes in MPOD in the left eye

In the left eye, subjects with high degree myopia in the control group showed a decrease in MPOD from  $0.64 \pm 0.16$  before the supplementation of control food to  $0.63 \pm 0.14$  after 6 months of the supplementation while those in the experimental group, unlike the control group, showed a statistically significant increase from  $0.60 \pm 0.14$  before the supplementation of lutein to  $0.70 \pm 0.09$  after 6 months after the supplementation ( $p = 0.014$ ,  $t = 2.810$ ).

Subjects with moderate degree myopia in the control group and the experimental group both showed an increase in MPOD in the left eye from  $0.65 \pm 0.09$  to  $0.71 \pm 0.14$  and from  $0.63 \pm 0.15$  to  $0.65 \pm 0.16$  before and after the supplementation. However, there was no significant difference ( $p = 0.598$ ,  $t = 0.535$ ).

Subjects with low degree myopia in the control group showed a decrease in MPOD from  $0.63 \pm 0.09$  before the supplementation to  $0.62 \pm 0.14$  after 6 months of the supplementation while those in the experimental group showed a statistically significant increase from  $0.60 \pm 0.13$  before the supplementation to  $0.66 \pm 0.08$  after 6 months after the supplementation ( $p = 0.041$ ,  $t = 2.177$ ) (Table 4, Table 5 & Fig. 4).

## 3. Changes in distance visual acuity

The control group showed a slight decrease in the distance visual acuity in both eyes from  $0.54 \pm 0.52$  before the supplementation to  $0.53 \pm 0.53$  after 6 months of the supplementation while the experimental lutein group showed no statistically significant difference from  $0.41 \pm 0.50$  before the supplementation to  $0.41 \pm 0.47$  after the supplementation ( $p > 0.005$ ,  $t = -0.219$ ) (Table 5). Unlike this study, however, a study conducted by Piermarocchi has reported that the group supplemented with lutein 10 mg and zeaxanthin 1 mg for 2 years showed improvement in the visual acuity.<sup>[28]</sup> Thus, the insignificant change of visual acuity in this study is considered to be derived from the short period of supplementation, which lasted only for 6 months, and further studies with a longer period of time are considered to be needed.

## 4. Changes in near visual acuity

The near visual acuity in the control group was  $0.57 \pm 0.39$  before the supplementation of control food and  $0.61 \pm 0.40$  after the supplementation, and that in the experimental lutein group was improved from  $0.47 \pm 0.38$  before the take of lutein to  $0.55 \pm 0.40$  after the supplementation with a statistically significant difference ( $p = 0.001$ ,  $t = 3.419$ , Table 6).

## 5. Changes in contrast sensitivity and MPOD

In case of the contrast sensitivity (at 3 / 6 / 12 / 18 cpd) in both eyes, the control group showed a decrease from  $5.87 / 5.23 / 4.40 / 4.52$  before the supplementation to  $5.70 / 4.90 / 4.13 / 4.10$  after 6 months of supplementation while the experimental group showed  $5.72 / 5.05 / 4.05 / 3.97$  before the supplementation of lutein and  $5.82 / 5.07 / 4.17 / 4.02$  after 6 months of the supplementation. The contrast sensitivity comparison between before and after the supplementation in the control group and the experimental group showed no statistically significant difference with  $p > 0.05$  (Table 8, Table 9). However, as suggested in Figure 5 and

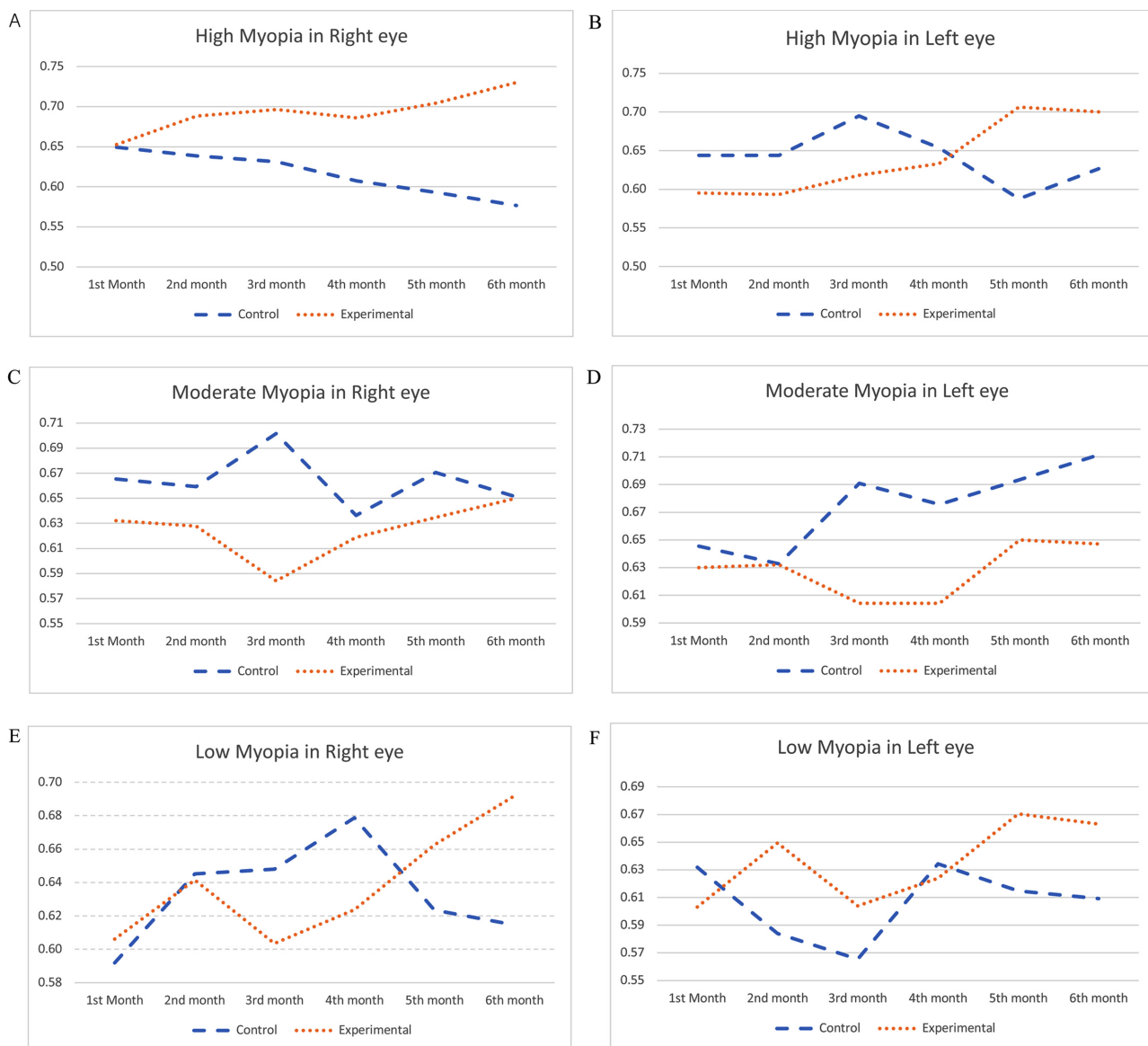


Fig. 4. Change in macular pigment optical density stratified by myopia classification in OD and OS.

Table 6. Comparison between distance visual acuities of the control and the experimental groups after 6 months

		Mean	±SD	t	df	p
Control	OD Distance VA	0.01	0.24	0.256	59	0.799
	OS Distance VA	0.03	0.24	1.085	59	0.282
	OU Distance VA	-0.01	0.25	-0.223	59	0.824
Experimental	OD Distance VA	0.01	0.28	0.235	58	0.815
	OS Distance VA	0.00	0.26	-0.006	58	0.995
	OU Distance VA	-0.01	0.29	-0.219	58	0.828

Table 1, the control group showed decreasing trends at all cpd in the right eye, the left eye, and the both eyes while the experimental group showed improvement at all cpd expect the high frequency in the right eye when before and

Table 7. Comparison between near visual acuities of the control and the experimental groups after 6 months

		Mean	±SD	t	df	p
Control	OD Near VA	0.04	0.22	1.332	59	0.188
	OS Near VA	0.02	0.23	0.559	59	0.578
	OU Near VA	0.03	0.20	1.134	58	0.261
Experimental	OD Near VA	0.02	0.23	0.630	57	0.531
	OS Near VA	0.04	0.23	1.392	57	0.169
	OU Near VA	0.09	0.19	3.419	56	0.001

after the supplementation were compared. Studies including one by Yao reported that the supplementation of lutein 20 mg for 1 year improved the contrast sensitivity with a statistically significant difference although the improvement

Table 8. Comparison between contrast sensitivities of the control group at baseline and after 6 months

	Mean	±SD	t	df	p
3sf	-0.167	0.994	-1.298	59	0.20
6sf	-0.333	1.591	-1.623	59	0.11
12sf	-0.267	1.982	-1.042	59	0.30
18sf	-0.417	1.862	-1.733	59	0.09

Table 9. Comparison between contrast sensitivities of the experimental group at baseline and after 6 months

	Mean	±SD	t	df	p
3sf	0.103	1.038	0.759	57	0.45
6sf	0.069	1.61	0.326	57	0.75
12sf	0.19	2.148	0.673	57	0.50
18sf	0.138	2.03	0.517	57	0.61

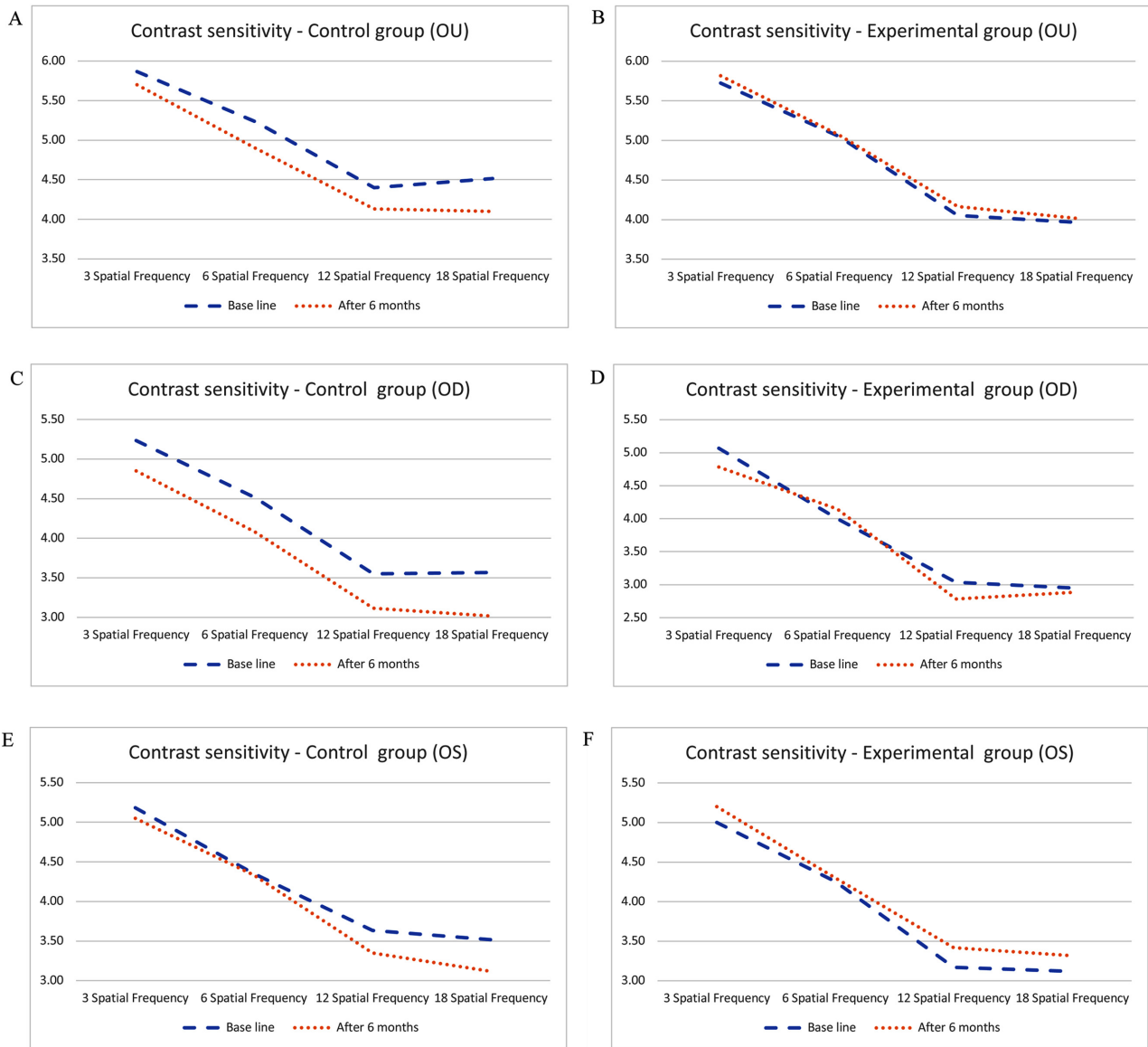


Fig. 5. Comparison of contrast sensitivities in the control and the experimental groups.

in the corrected vision showed no statistically significant difference.<sup>[29]</sup> Also, studies including one by Ma reported that the group supplemented with lutein 20 mg for 48 weeks showed improvement in the contrast sensitivity.<sup>[30]</sup> The differences between this study and preceding studies are considered to be derived from the short period of sup-

plementation and further studies with a longer period of time are considered to be needed.

### Conclusion

Since Koreans in their 20s have very low consumption



levels of green and yellow vegetables as their diets have been westernized and as this age group is over-exposed to blue light almost all day from digital devices including smart-phones or in-house lightening from LEDs, the conditions are expected to influence their eye sight impacted by reduced MPOD levels. This study was conducted for this reason.

This study investigated the MPOD of 60 subjects in the control group and 60 subjects in an experimental lutein group. The control group showed almost no change in MPOD in both eyes between before and after the supplementation while the experimental lutein group showed a statistically significant increase in the same measurements. The MPOD according to the degree of myopia also showed greater improvement in subjects with high and low myopia in the experimental group when compared to the control group. Middle myopia showed slightly improvement. but, were not statistically significant. Preceding studies have shown that intake of lutein & zeaxanthin for 1 to 2 years resulted in significant changes. Therefore, it is assumed that further research is needed.

In addition, the experimental group showed a statistically significant increase in the near visual acuity and greater improvement in the contrast sensitivity than the control group when the measurements between before and after the supplementation were compared. Although not statistically significant, the control group was a slight decrease in distance visual acuity after six months, while the experimental lutein group was neither increase nor decrease in distance visual acuity. This shows that taking lutein and zeaxanthin has a fine effect on vision. Therefore, further research is needed. Even in the same subject's eyes, the right eye and the left eye's corrective vision will be different. When lutein & zeaxanthin were taken, the reactions in the right eye and left eye were measured slightly differently.

Preceding studies have shown that lutein increased MPOD and the speed was significantly faster in the experimental group supplemented with lutein than the control group. It is also reported that the change rate of MPOD was higher as the starting MPOD was lower in the experimental group.<sup>[31]</sup> In a study conducted by Hammond, the experimental group supplemented with lutein 10 mg and zeaxanthin 2 mg for 1 year showed a significant increase in MPOD, contrast sensitivity, and recovery speed from light stress.<sup>[11]</sup>

These studies demonstrated that the supplementation of lutein and zeaxanthin relieves the damage of retina caused by light oxidative stress by absorbing blue light. The mechanism was proven to improve the contrast sensitivity and relieve the light stress, which are functions of fovea centralis.

The result of this study also showed that the 6-month supplementation of lutein 20 mg and zeaxanthin 1.5 mg in Koreans in their 20s improved the MPOD, degree of myopia, near visual acuity, and some contrast sensitivities.

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## 20대 성인에서 루테인 섭취 후 황반색소광학밀도 및 시각기능 변화

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**목적:** 20대 성인에서 루테인(지아잔틴 포함) 섭취가 황반색소광학밀도(macular pigment optical density; MPOD)향상과 시각기능 개선에 영향이 있는지 알아보려고 하였다. **방법:** 전신질환이나 특별한 안질환(황반색소변성 및 백내장)이 없는 20대 성인 120명(실험군 60명, 대조군 60명)을 대상으로 실시하였다. 실험군은 루테인을 대조군은 대조식품인 대두유를 동일한 알약형태로 6개월간 1일 1회씩 섭취하였다. 각각의 식품을 섭취한 후 MPOD를 Macular Pigment Screener II(MPS II ®)를 이용하여 매일 측정하였으며, 원거리와 근거리 나안시력, 굴절이상량(S.E), 그리고 대비감도 시력은 각각의 식품 섭취 전과 6개월 섭취 후에 측정하여 결과를 비교해 보았다. **결과:** 대조군의 경우 대조식품 섭취 전 양안 MPOD는  $0.64 \pm 0.10$ 이었고 6개월 섭취 후는  $0.63 \pm 0.13$ 으로 감소한 반면, 실험군의 경우 루테인 섭취 전 양안 MPOD는  $0.62 \pm 0.11$ 이었고 6개월 섭취 후는  $0.68 \pm 0.12$ 로 루테인을 섭취한 실험군의 MPOD가 통계적으로 유의하게 증가하였다( $p=0.000$ ,  $t=4.554$ ). 근시 정도별로는 고도, 약도 근시는 루테인을 섭취한 실험군이 통계적으로 유의하게 향상된 것으로 나타났으나(우안: 고도  $p=0.029$ ,  $t=2.435$ , 약도  $p=0.000$ ,  $t=4.160$  / 좌안: 고도  $p=0.014$ ,  $t=2.810$ , 약도  $p=0.041$ ,  $t=2.177$ ), 중도 근시에서는 유의하지 않았다(우안:  $p>0.05$ ,  $t=0.569$ , 좌안:  $p>0.05$ ,  $t=0.535$ ). 근거리 양안 나안시력은 루테인을 섭취한 실험군에서 섭취 전과 비교하여 통계적으로 유의하게 향상된 것으로 나타났다( $p=0.001$ ,  $t=3.419$ ). 대비감도 시력은 루테인을 섭취한 실험군의 경우 우안 고주파수대 일부를 제외하고 우안, 좌안, 양안 대부분의 주파수에서 향상되는 것으로 나타났으나, 대조군의 경우 우안, 좌안, 양안 모든 주파수에서 감소하는 경향이 나타났다. **결론:** 이러한 결과로 볼 때, 6개월간의 루테인 섭취가 황반색소광학밀도(MPOD) 향상에 효과가 있었으며, 근시정도, 근거리 나안시력, 일부 대비감도 시력 등의 시각기능이 향상되는 것을 알 수 있었다.

**주제어:** 황반색소광학밀도, 루테인, 지아잔틴, 대비감도시력