# Correlation between 25-Hydroxy Vitamin D Serum Levels with Contrast Sensitivity, Color Vision and Visual Fields in Moderate-High Myopia

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**Abstract.** *Background:* Myopia is a visual impairment problem that constantly increases, causing public health problems and economic burdens globally. Previous studies have shown that vitamin D deficiency is associated with decreased visual acuity as well as visual function.

*Objective:* To determine the correlation between 25-hydroxy vitamin D serum levels with contrast sensitivity, color vision, and visual fields in moderate-high myopia.

*Methods:* This study was an observational analytic study with a cross-sectional design. Visual function tests performed were visual acuity test, Pelli-Robson contrast sensitivity chart, pseudoisochromatic Ishihara, Humphrey visual field analyzer, and ELISA test for 25(OH)D.

*Results:* The sample of this study was 50 subjects with moderate to high myopia consisting of 39 females (60%) with a mean age of 26.62±3.70 years. The distribution of moderate myopia and high myopia was 30% and 20% with a mean spherical equivalent of -5.11±1.54 D. Spearman correlation analysis found no statistically significant correlation between serum 25(OH)D and contrast sensitivity (p=0.132, r=0.216). Color vision was homogeneous in all patients, Fischer's exact analysis of the visual field in the right eye (p=0.001), and in the left eye (p=0.132). Subjects with vitamin D deficiency were 24 patients (48%), and with vitamin D insufficiency was 1 subject (2%), with an average level of 25(OH)D 44.56±41.45 ng/ml.

*Conclusions:* Serum levels of 25-hydroxy vitamin D were not correlated to contrast sensitivity and color vision. However, a significant correlation between 25-hydroxy vitamin D serum levels with the visual field in one eye was found.

**Keywords:** 25-hydroxy vitamin D, visual function, moderate and high myopia

## Introduction

Refractive errors are one of the most common causes of visual impairment worldwide and are the second leading cause of treatable blindness (Brodie et al., 2019). Uncorrected refractive errors are the leading cause of moderate and high visual impairment worldwide (52.43%) and are the second cause of blindness (20.28%) after cataracts (35.15%) (Brar et al., 2019; Flaxman et al., 2017).

Based on the Rapid Assessment of Avoidable Blindness (RAAB) study, uncorrected refractive errors in Indonesia are the second cause of moderate visual impairment (36.8%), after cataracts (73.5%) (Sari et al., 2016). Myopia is defined as a mismatch between the optical power and the length of the eyeball, that the created image drops in front of the retina and produces a blurred image on the retina (Skowron et al., 2018; Mutti et al., 2011).

Vitamin D is thought to have a role in the development of myopia. The results of Choi et al study found that serum vitamin d levels decreased in high myopia (Choi et al., 2014). Mutti study in 2011 found that myopia patients had vitamin D levels of 3.4 ng/ml lower than non-myopia patients (Mutti et al., 2011). Yazar's study in 2014 showed that in myopia vitamin D3 is lower than non-myopia with vitamin D3 levels lower than 50 ng/mL (Yazar et al., 2014). In contrast to William's study in 2017, that there is no relationship between serum vitamin D values on the development of myopia (William et al., 2017). Similarly, Kearney

study in 2019 found that there was no relationship between vitamin D3 levels and the patient's refractive status (Ozturk, 2020).

The quality of vision can be known through examinations of contrast sensitivity, color vision, and visual field. Myopia patients usually get a problem with visual function (Yazar et al., 2014). Ozturk et al's study, patients with vitamin D deficiency have low score in contrast sensitivity especially moderate to high myopia (Ozturk, 2020). In contrast, Dalton study reveal thay low vitamin D levels has no relation with visual function (Ozturk, 2020).

Liou and Chiu in 2001 study of mild and moderate myopia patients showed normal contrast sensitivity and with high myopia, there was decreased contrast sensitivity. Bistra's study in 2007 contrast sensitivity decreased with increasing degree of myopia, such as moderate and high myopia (Liou et al., 2001; Qian et al., 2009).

The Qian study in 2009 found a low incidence of color vision defects in myopic patients due to decreased function of the chromatic mechanism in cone cells (Qian et al., 2009). Lee's study in 2013 of color vision defects showed a fewer amount compared to normal vision, in protanopia and deuteranopia by 1.68% and 2.28%, concluding that there was no significant relationship between moderate and high myopia (Lee et al., 2013). In contrast, Zhale Rajavi's study in 2015 no association between amblyopia, refractive error, anisometropia, or strabismus with color vision impairment (Rajavi, 2015)

Goncalves's study in 2015 there is correlation between vitamin D deficiency and primary open-angle glaucoma. Rabie's study in 2020, the relationship between visual field defects in moderate to high myopia was visual field defects localized to the temporal, nasal, and inferior quadrants (Rab'ie Rusdil et al., 2020). Ding et al study in 2016 explained that in high myopia there is visual field disturbance (Ding et al., 2016).

## Methods

### Study Design

This study was an observational study with cross-sectional design. The study was done in the Eye Clinic, University of Sumatera Utara General Hospital, and satellite hospitals. The minimum subjects required was 50 patients and obtained through consecutive sampling. The sample was collected from July 2021 until November 2021. The inclusion criteria were moderate and high myopia aged between 18 and 40 years and had a spherical equivalent of a minimum -3.25 D. The exclusion criteria were patients with glaucoma, patients with a history of trauma, or previous eye surgery, patients with retinal disease, patients with an optic nerve disorder, history of eye infections such as keratitis, scleritis, uveitis, endophthalmitis and cellulitis, patients with amblyopia, patient with congenital color vision impairment, patients using drugs that affected color vision such as amiodarone, chlorpromazine, alcohol, hydroxychloroquine, indomethacin, and patients with a history of taking oral vitamin D supplementation in the last 2 weeks.

### Data Analysis

Univariate analysis is mean, median, standard deviation, minimum, and maximum for numbered variables such as age, and vitamin D3 levels. The distribution of variables such as gender, contrast sensitivity, color vision, and visual field was displayed with a number (n) and percentage (%).

Bivariate analysis take the correlation between vitamin D serum levels with visual function consist of contrast sensitivity, color vision, visual field for subjects myopia by using the Pearson test if the data were normally distributed, or the Spearman test if the data were not normally distributed, with a significance level of 5%.

**Results**

The data used were main data in the form of demographic data (gender and age) obtained through interviews, refraction status was obtained through visual examination, color vision data was obtained through Ishihara examination, perimetry examination was obtained through Humphrey Visual Field Test and contrast examination take with the Pelli Robson Chart, 25-hydroxy vitamin D serum levels were obtained using ELISA examination at the Integrated Laboratory of the Faculty of Medicine, University of Sumatera Utara.

**Demographic Characteristics of Research Subjects**

This study consisted 50 subjects who came to the Eye Clinic, University of Sumatera Utara General Hospital, and satellite hospitals. All subjects had fulfilled the inclusion criteria and the demographic characteristics are shown in Table 1.

**Table 1. Demographic Characteristics of Research Subjects**

| Demographic Characteristics | N = 50 |
|---|---|
| Gender, n (%) | |
| Men | 20 (40) |
| Women | 30 (60) |
| Age, Year | |
| Average±SD | 26.62±3.70 |
| Median (Min – Max) | 25 (21 – 36) |
| Myopia degree, n (%) | |
| Moderate | 30 (60) |
| High | 20 (40) |

Most of the subjects were female with 30 subjects (60%). The mean age of the subjects was 26.62±3.70 years with the youngest was 21 years old and the oldest was 36 years old. From the results of the eye examination, there were 30 subjects with moderate myopia and 20 subjects with high myopia.

**Eye Examination Results and Serum Levels of 25 OH Vitamin D**

Table 2 presented the results of the spherical equivalent examination, color vision value, PSD perimetry, contrast sensitivity and serum levels of 25-hydroxy vitamin D in the right eye and left eye of patients with myopia.

**Table 2. Results of Eye Examination and Serum Levels of 25 OH Vitamin D**

| Results of Eye Examination | n = (%) |
|---|---|
| Spherical equivalent right | |
| Mean±SD | -5.11±1.54 |
| Median (Min – Max) | -4.75 (-9.5 - -3.25) |
| Spherical equivalent left | |
| Mean±SD | -5.14±1.65 |
| Median (Min – Max) | -4.5 (-9.25 - -3.25) |
| Binocular Color Vision Value | |
| Normal | 50 (100) |
| Red green color blindness | 0(0) |
| Right Eye PSD Perimetry | |
| Normal | 43 (86) |
| Abnormal | 7 (14) |

| | |
|---|---|
| Left Eye PSD Perimetry | |
| Normal | 42 (84) |
| Abnormal | 8 (16) |
| Right Eye Contrast Sensitivity | |
| Mean±SD | 1.82±0.19 |
| Median (Min – Max) | 1.85 (1.4 – 2) |
| Normal, n (%) | 29 (58) |
| Decrease, n (%) | 21 (42) |
| Left Eye Contrast Sensitivity | |
| Mean±SD | 1.82±0.19 |
| Median (Min – Max) | 1.85 (1.4 – 2) |
| Normal, n (%) | 29 (58) |
| Decrease, n (%) | 21 (42) |
| 25-hydroxy Vitamin D serum levels, ng/mL | |
| Mean±SD | 44.56±41.45 |
| Median (Min – Max) | 31.9 (6.6 – 152.5) |
| Deficient | 24 (48) |
| Insufficient | 1 (2) |
| Normal | 25 (50) |

The mean spherical equivalent in right eye was -5.11±1.54 and left eye was -5.14±1.65. The results of binocular color vision examination showed normal results in all subjects. Perimetry of the PSD of the right eye showed most subjects was normal with 43 subjects (86%) in the right eye and 42 subjects (84%) in the left eye. The contrast sensitivity value in the right eye showed a mean of 1.82±0.19 and in the left eye showed a mean of 1.82± 0.19. Twenty nine subjects (58%) had normal contrast sensitivity in the both eyes. Serum levels of 25-hydroxy vitamin D in 50 subjects had an average of 44.56±41.45 ng/mL with the lowest value of 6.6 ng/mL and the highest value of 152.5 ng/mL. Almost half of myopia subjects showed deficiency of 25-hydroxy vitamin D serum levels amounted 24 subjects (48%) and 1 subject with insufficiency 25-hydroxy vitamin D serum levels, while 25 otheras had normal 25-hydroxy vitamin D serum levels.

**Relationship Between Serum Levels of 25-Hydroxy Vitamin D on Contrast Sensitivity Values, Color Vision, Field of View in Patients with Moderate to High Myopia**

**Table 3. Relationship Between Serum Levels of 25-Hydroxy Vitamin D and Contrast Sensitivity Values in Patients with Moderate to High Myopia**

| | | Contrast Sensitivity | |
|---|---|---|---|
| | | **p*** | **r** |
| 25-hydroxy vitamin D serum levels | Right Eye | 0.132 | 0.216 |
| | Left Eye | 0.132 | 0.216 |

Note: *Spearman's Correlation

Table 3 There was no significant association between 25-hydroxy vitamin D serum levels and contrast sensitivity values both in the right eye and left eye (p=0.132). By using different statistical methods, the same results can be obtained that there was no relationship between serum 25-hydroxy vitamin D and the contrast sensitivity value (p = 0.271) as shown in Table 4.

**The Association between 25-Hydroxy Vitamin D Serum Levels on Right Eye and Left Eye Color Vision in Subjects with Moderate to High Myopia**

This relationship was shown in table 2 that the color vision variable has homogeneity. With this homogeneity, there was no association between 25-hydroxy vitamin D serum levels and color vision.

**Table 4. Relationship Between Serum Levels of 25-Hydroxy Vitamin D on Contrast Sensitivity Values of Right and Left Eyes in Patients with Moderate to High Myopia**

| Vitamin D | Contrast Sensitivity | | p* |
|---|---|---|---|
| | Down | Normal | |
| Defisiency and Insufisiency | 12 (50) | 12 (50) | 0.271 |
| Normal | 9 (34.6) | 17 (65.4) | |

Note: *Chi Square

**Table 5. The relationship between serum levels of 25-hydroxy vitamin D with visual field in the right eye and left eye.**

| Perimetry PSD | 25-Hydroxy Vitamin D Serum, ng/mL | | p* |
|---|---|---|---|
| | Mean±SD | Median (Min-Max) | |
| Right Eye | | | |
| Normal | 50.32±41.98 | 39.8 (6.6-152.5) | 0.004 |
| Abnormal | 9.23±1.03 | 9.02 (8.12-11.1) | |
| Left Eye | | | |
| Normal | 48.01±41.35 | 39.3 (6.6-152.5) | 0.060 |
| Abnormal | 26.47±39.55 | 9.5 (8.12-121.4) | |

Note: *Mann Whitney

In Table 5, the normal right eye had a mean serum vitamin D level of 50.32 ng/mL, while in the right abnormal eye, there was a lower mean vitamin D serum level of 9.23 ng/mL. There was a significant relationship between 25-hydroxy serum vitamin D levels and the visual field in the right eye (p=0.004). In the left eye, the normal eye had a mean serum vitamin D level of 48.01 ng/mL, while in the abnormal eye the lower average 25-hydroxy vitamin D serum levels in the subject were 26.47 ng/mL. There was no significant relationship between serum levels of 25-hydroxy vitamin D and the visual field in the left eye (p=0.060).

**Discussion**

In this study, female subjects were more than male subjects with 30 female subjects (60%). Similar to Choi study and Mutti study stated that myopia percentage in females is higher than males with the percentage varying from 55% to 60% (Mutti et al., 2011; Choi et al., 2014). This was due to various factors such as females tended to read more, did more close activities, and had less exposure to sunlight. Most myopia degree in the subjects was moderate myopia with 30 subjects (60%) and high myopia with 20 subjects (40%). Similar to several studies, Choi et al study found moderate myopia subjects was 29% while high myopia was 8.9%. Bussa's study in India with the percentage of moderate and high myopia of 79.7% and 17.7%, respectively. Gao's study in 2021 with the percentage of mild, moderate, and high myopia of 49.4%, 46.7%, and 3.7%. Jung's study in 2020 with the percentage of mild, moderate myopia, and high myopia with 55%, 40.3%, and 4.7% (Choi et al., 2014; Bussa et al.,2019; Gao et al., 2021; Jung et al., 2020).

The average contrast sensitivity value is 1.82±0.19. From 29 subjects (58%) results were normal and 21 subjects (42%) had decreased contrast sensitivity (20 subjects with high myopia, 1 with moderate myopia). Similar to Yi study that the average contrast sensitivity was 1.62± 0.11. Liow and Chiu study showed that mild and moderate myopia subjects had normal contrast sensitivity and the high myopia subjects had decreased contrast sensitivity. This study found that there was no significant relationship between 25-hydroxy vitamin D levels and the value of contrast sensitivity in patients with moderate to high myopia with a correlation value of 0.216 (p=0.132) in the right and left eyes. Similar to Dalton et al's study in 2017 that there was no relationship between vitamin D serum and decreased contrast sensitivity. In contrast to Oztruk's study in 2020 stated that there was a relationship between 25-hydroxy vitamin D levels and decreased contrast sensitivity at spatial frequency 6, 12, and 18 cpd, respectively (p = 0.004, p = 0.001, p = 0.042) (Ozturk et al., 2001).

The results of color vision from all subjects are normal and no color blindness was found. there was no correlation between 25-hydroxy vitamin D serum levels with color vision. Similar to Zhale et al's study in 2015 explained that was no assosiation between color vision defects with a type of amblyopia, refractive error, anisometropia, and ocular deviation (p=0.185). Lee's study in 2013 showed no association between color vision and high myopia (p=0.904, OR 0.96, 95%CI) even if color vision deficiency have tendency for low myopia (Qian et al., 2009; McCulley et al., 2016).

Based on Table 2, the standard deviation pattern in the right eye was 43 subjects with a normal visual field (86%), and 7 subjects with an abnormal visual field (14%). The right eye with localized visual field defects included: 3 eyes with inferior visual field defects, 2 eyes with nasal defects, and 2 eyes with temporal defects. In the left eye visual field, there were 42 subjects with normal results (84%) while 8 subjects (16%) had localized visual field defects including 4 eyes with inferior visual field defects, 2 eyes with nasal defects, 2 eyes with temporal defects. This result was similar to Rabie's study in 2020 that the degree of myopia affected all quadrants of the visual field, and the defected area was more focused on the inferior, temporal, and nasal visual fields.

In our study, there was a significant assosiation between 25-hydroxy vitamin D levels and the right eye visual field and it was found no significant correlation between 25-hydroxy vitamin D levels and the left eye visual field. The difference in the results of the analysis from the right eye was significant because high myopia subjects with vitamin D deficiency were more than the left eye subjects. This was similar to Rabie's study in 2020 that there was a significant relationship between visual field defects in high myopia. Goncalves's study in 2015 explained that there was a decrease in the serum level of vitamin D in POAG patients (p=0.039), but there was no correlation between the visual field functions for each degree of POAG (p=0.200). Mathieu's study in 2015 revealed vitamin D deficiency in older age had decrease in GCC thickness (p=0.017) (Mathieu Uro et al., 2015; Goncalves Dan Milea et al., 2015).

There were several limitations in this study: this study did not perform matching, which aimed to equalize the number of patients with the degree of myopia, the number of unilateral eye defects, and bilateral eye defects. Moreover, the limitations of this study did not included outdoor or indoor activity as an important factor affecting serum vitamin D levels. In subjects with homogeneous color vision values, samples with color vision defects could be added to be used as comparisons.

## Conclusions

Myopia subjects were most female with 30 subjects (60%) compared to male with 20 subjects (40%) and the average age was 26.46±3.71 years old. The most found degree of myopia was moderate myopia with 30 subjects (60%), and high myopia with 20 subjects

(40%). There was no assosiation between 25-hydroxy vitamin D serum levels and contrast sensitivity. There was no assosiation between 25-hydroxy vitamin D serum levels and color vision. There was an assosiation between the 25-hydroxy vitamin D serum levels and the visual field in the right eye.

**Acknowledgement**

The authors are deeply indebted to the Medical Faculty of University of Sumatera Utara and University of Sumatera Utara General Hospital for providing equipment and scientific apparatus in the conduct of this study.

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