ORIGINAL ARTICLE

The Effect of Vitamin-D and Sunlight to Progressive Myopia in Students with Glasses Correction

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ABSTRACT

Aim: To analyse the effect of vitamin D supplementation and sunlight exposure to myopia progressivity in junior high school students with glasses correction.
Study Design: Quasi Experiment with Pre-Post Test Control Group Design
Methods: eighty students, divided into 4 groups (X1: vitamin D supplementation, X2: sunlight exposure, X3: combination of supplementation and sunlight, X4: control). Difference tests among groups were analyzed by Wilcoxon and Kendall's tau-b.
Result: There was an increase of 25-hydroxyvitamin D at all groups. But a significant difference was only in X3 ($p < 0.05$). A decreased myopia degree after intervention occurred at all intervention groups both right and left eyes. While the significant differences in groups X2 and X3 for the right eye, and group X1, X2, and X3 for the left eye ($p < 0.05$).There was significant association between 25-hydroxyvitamin D and myopia progressive, with correlation value of X1 (ODS = 0.0001) X3 (OD = 0.046 OS = 0.004). There was a significantly strong negative association between a combination of supplementation and sunlight exposure with OD myopia progressivity ($P < 0.05$).
Conclusion: Vitamin D supplementation and sunlight exposure could increase serum 25-hydroxyvitamin D, decrease myopia, and inhibit the progression of myopia.
Keywords: Vitamin D, sunlight, myopia, junior high students

INTRODUCTION

Vitamin D in school-ages needs to be considered because the means of 2.0-12.9 years old showed 52.6 ± 0.7 nmol/L. The prevalence of insufficiency vitamin D (25-49 nmol/L) is 45.1%, inadequate (50-74 nmol/L) is 49.3%, and desirable (>75 nmol/L) is 5, 6%. Vitamin D were higher in boys 54.7 ± 0.9 nmol/L than girls 49.9 ± 1.0 nmol/L. There is positive association between the length of outdoor activities and the level of vitamin D. Vitamin D in children who living in urban and industrial areas (52.5 nmol/L) has similarities with rural areas (52.6 nmol/L)[1].

Vitamin Dinsufficiency and inadequate vitamin D has not yet become a concern in Indonesia. Not many studies in Indonesia about vitamin D in children and other populations. The increase of deficiency and inadequate vitamin D prevalence caused by low vitamin D intake , tendency to limit high-fat foods – lowvitamin Dabsorption, increased sunscreen use, and less exposure of sunlight due to lack of outdoor activity[2].

Vitamin D in the eye was first identified by the presence of a vitamin D-dependent calcium-binding protein, or calbindin, which is expressed throughout the retina. Immunohistochemical staining identified the presence of VDR in the corneal epithelium, lens, ciliary bodies, and retinal pigment epithelium, as well as corneal endothelium, ganglion cell lining, and retinal photoreceptors[3]. Eye cells have abilities to activate and regulate the metabolism of vitamin D. Most cell types were found could able to convert functionally active $25D_3$ to $1{,}25D_3$[4].

Vitamin D deficiency impacts on lower 25-hydroxyvitamin D concentrations which is associated with a higher risk of myopia.The prevalence of myopia is significantly higher on people with vitamin D deficiency than with adequate levels[5,6]. The causes and mechanisms of myopia arise mainly due to keratoconus, which is an extreme presentation of a common corneal disorder related to lack of vitamin D. Myopia is the end result of unsuccessful feedback emmetropization due to low irregular corneal astigmatism associated with vitamin D[7].

There was a significant relationship between serum 25-hydroxyvitamin D levels with the axial length of the eyeball and the risk of myopia. Children with low serum 25-hydroxyvitamin D had a longer axial axis size, and higher 25-hydroxyvitamin D had smaller risk of myopia. The risk of myopia decreased with the increasing of serum 25-hydroxyvitamin D to 25 nmol/L[8].

Corneal limbal epithelial cells capable of producing vitamin D, de novo, in culture when exposed by ultraviolet B - similar with skin cells, potentially providing local source of vitamin D to the surface of the eye. Other sources of vitamin D in the eye from fluid and tear films containing the vitreous and fluids. Vitamin D metabolites have been shown to be present in rabbits and increased with oral vitamin D supplementation[9].

There are many evidences that vitamin D is function to eye health, with the expression of receptor-regulating enzymes and vitamin D throughout the eye. This study aimed to analyze the effect of vitamin D supplementation and sunlight exposure with myopia progressivity in junior high school students with glasses correction.

METHOD

This study used quasi-experimental design with pre-post test control group approach. Ethical clearance approval received from Health Research Ethics Committee Faculty of Medicine Universitas Diponegoro with number 490/EC/KEPK/FK-UNDIP/XI/2019.

This study was conducted in Semarang, Central Java, Indonesia on Junior High School aged 12-15 years. The schools chosen purposively and conducted on 83 students with the inclusion criteria were: 1) suffering from moderate to high myopia (-2.00 D to ≥-6.00 D detected by autorefractometer measurement with correction lenses reaching 6/6, 2) willing to be examined during the study confirmed by informed consent. Participants were excluded from the study were advanced age-related macular degeneration (AMD), aphakia or pseudophakia in both eyes, or visual disturbances i.e., less than 0.5 logMAR or 20/60 Snellen acuity or less due to cataracts. Students who have a history of glaucoma and other eye defects are not considered.

The subjects divided into 4 groups: 1) Group 1 (X1) given vitamin D supplementation 400 IU per day according to a doctor's prescription during 12 weeks, 2)Group 2 (X2) sunlight exposure. Students are asked to sunbathe for 20 minutes during the second break, 11:30 am exposed to sunlight without sunscreen three times/week during 12 weeks, 3) Group 3 (X3) combination between vitamin D supplementation and sunlight exposure, and 4) Group 4 (C) students who were not treated or the control group.

The variables collected included data on the degree of myopia using an autorefractometer. 25-hydroxyvitamin D serum data were taken from examination of blood samples, which were analyzed by the GAKI Universitas Diponegoro Laboratory. Serum 25-hydroxyvitamin D2 (25 [OH] D2) concentration was measured by liquid chromatography-tandem mass spectrometry. Normality test using the Shapiro Wilk. Data was analysed with Wilcoxon and Kendall's tau b test.

RESULTS

Most of the subjects were girls (73.5%).There was an increase of 25-hydroxivitamin D serum in all groups. Group X1 was given vitamin D supplementation increase from 33.60 nmol/L to 35.95 nmol/L, while the sun exposure group (X2) increased from 28.50 nmol/L to 30.00 nmol/L. There was increase also in the combination group (X3) from 27,80 to 29.95 nmol/L and group C from 28.30 to 33.00 nmol/L. The significant difference of 25-hydroxivitamin D serum before and after treatment is only in group 3 (X3) who were given combination between supplementation and sunlight exposure (p=0.033, p <0.05), whereas the others groups had no significant differences (p> 0.05) (see table 1).

A decreased myopia degree after intervention occurred at all intervention groups both right and left eyes. While the significant differences in groups X2 (p=0.012) and X3 (p=0.001) for the right eye, and group X1 (p=0.004), X2 (p=0.006), and X3 (p=0.001) for the left eye (p <0.05). There was no change in myopia degree of the right eye in the control group, meanwhile, there was an increase of myopia in the left eye.

Table 2 showed that there was association between serum 25-hydroxyvitamin D levels and myopia progression, especially for the group X1 who given vitamin D supplementation and group X3. Association both on two eyes. The closeness was very weak in the group given vitamin D supplementation, but increased in the group X3 who given supplementation and sunlight exposure both on right and left eye. In addition, the direction of association showed the opposite, which means the increase of vitamin D supplementation and sunlight exposure will decrease or inhibit the progression of myopia.

Table 3 showed that there was significant association between vitamin D supplementation and exposure to sunlight (X3) with the progression of myopia on the right eye (P <0.05). The two treatments also showed the strong relationship with myopia progressivity, which means more often the treatments were given, the myopia could be suppressed.

Table 1. Characteristics of subjects

Variables	X1 (n=20)	X2 (n=20)	X3 (n=20)	C (n=23)
Sex				
Boys	7	5	4	6
Girls	13	15	16	17
Serum 25-hydroxivitamin D level				
Pretest	33.6	28.5	27.8	28.30
Posttest	35.95	30.00	29.95	33.00
p-value	0.088	0.205	**0.033**	0.059
Dioptric myopia of right eye				
Pretest	-3.25	-3.52	-4.00	-3.52
Posttest	-3.05	-3.30	-2.40	-3.52
P-value	0.056	**0.012**	**0.001**	0.977
Dioptric myopia of left eye				
Pretest	-3.02	-3.15	-3.08	-3.51
Posttest	-2.84	-2.91	-2.16	-3.65
p-value	**0.004**	**0.006**	**0.001**	0.220

Table 2. Correlation of serum 25-hydroxivitamin D level and myopia progressivity

Variables	X1 (n=20)	X2 (n=20)	X3 (n=20)	C (n=23)
Right eye				
Correlation	0.000	-0.061	-0.459	0.000
Sig	**0.000**	0.792	**0.046**	**0.000**
Left eye				
Correlation	0.000	0.174	-0.667	0.000
Sig	**0.000**	0.448	**0.004**	**0.000**

Table 3: Correlation of myopia degree and myopia progressivity

Variables	X1 (n=20)	X2 (n=20)	X3 (n=20)	C (n=23)
Right eye				
Correlation	-0.169	-0.176	-0.459	-0.159
Sig	0.445	0.435	**0.046**	0.442
Left eye				
Correlation	0.020	-0.231	0.188	0.218
Sig	0.929	0.448	0.405	0.298

DISCUSSION

25-hydroxyvitamin D serum levels and progression of myopia: There was a decrease in myopia progressivity with an increase of 25-hydroxyvitamin D serum in group X1, X2 and X3. While, group C as a control there was no significant increase. Supplementation given at a dose of 400 IUday for 12 weeks, can reduce the progression of myopia by increasing serum 25-hydroxyvitamin D levels higher than without supplementation. The increase that occurred after supplementation was in accordance with Bae's study that performed vitamin D supplementation in patients with Dry Eye Syndrome (DES) with refractive errors and vitamin D deficiency.A total of 105 patients who were given intramuscular cholecalciferol injection (200,000 IU) showed an increase in 25-hydroxyvitamin D (25 (OH) D) with a mean of 25 (OH) D was 10.52 ± 4.61 ng/Ml[10].

Vitamin D supplements have been shown to increase tear secretion, reduce tear instability, and inflammation of the eye surface and eyelid. DES is an autoimmune disease characterized by immune and inflammatory processes that affect the ocular surface. DES is an inflammatory disease caused by activation of the innate inflammatory pathway in the eyeball surface cells and cytokines produced by T-helper (Th) cells[11].

TNF-α and IFN-production were significantly reduced by 1.25 (OH) 2 D3 through interference with the production of NF-κB 1.25 (OH) 2 D3 that had immune regulatory effects on NK cell cytotoxicity, cytokine secretion, degranulation processes, and the expression of TLR4[12].

The previous study concluded that 1,25 (OH) 2-Vitamin-D3 have been reported to attenuate the expression of cytokines associated with Th17[13], The 1,25 (OH) 2 D3 improved colon and spleen inflammation by decreasing the regulation of Th 1 and Th17 cytokines. The concentration of Th17 in tears of DES patients was significantly increased in which Th17 concentration is related to the severity of the disease[14].

The previous study by Ilhan et al stated that there was a relationship between Dry Eye Syndrome (DES) and myopia. Patients with myopia had lower TBUT (Tear Break Up Time) scores when compared to a healthy one. The sample was divided into two, group 1 totalled 45 patients with myopia greater than -6.0 diopters (D) and axial length (AL)> 26.5 mm, and group 2 of 44 healthy people were selected from subjects with emmetropia. There were significant differences between groups in SE, keratometry, AL, TBUT, and Ocular Surface Disease Index (OSDI) (P <0.001). Patients with pathological myopia had lower TBUT and higher OSDI scores if compared to healthy people[15].

Low of 25(OH)D concentration was also show associated with prevalence for myopia and high myopia, which was consistent with previous studies using KNHANES data[6,16]. The other studies also revealed that myopia correlates with lower vitamin D serum compared to non-myopia[5,17]

A large population-based study revealed that polymorphisms in vitamin D receptors were associated with low to moderate degrees of myopia. Because the endogenous synthesis of vitamin D is induced by sunlight, as a biomarker[18].

Vitamin D deficiency could also cause impaired relaxation and contraction of the ciliary muscles due to changes in intracellular calcium concentration, which lead to genopia myopia. In addition, vitamin D initiates the formation of VDR or heterodimeric acid, which participates in signalling pathways of retinoscleral that could affect the incidence of myopia[6].

Degree of Myopia and Myopia Progressivity: This study proved that there was a difference in the degree of myopia before and after treatment in the right and left eyes. Vitamin D supplementation and sunlight exposure have opposite direction with myopia degree. Initially, it was assumed that a combination of supplementation and sun exposure would inhibit myopia progressivity more. This finding showed that the hypothesis is proven. There was a significant difference in myopia degree in the right eye who given sun exposure and combination of the treatment. While in the left eye, there was a significant difference in all treatment groups.

This finding was in accordance with a study stated that the main factor of myopia was an increase the eyeball axial length due to a decrease of quantity and changes in the anatomical characteristics of the sclera collagen tissue. the change occurred because of lack nutrients and tissue building vitamins - dopamine, when stimulated by bright light would inhibit the axial growth of the eyeball. In addition, vitamin D, which is obtained from sunlight has a role in the formation of collagen as the main component of the sclera[19].

Group X1 and X2 were groups with sun exposure in which purple light, has a shorter wavelength than blue light and was a component of the light that was missing in modern society, could play an important role in myopia control. The lower limit of visible light is defined between 360 and 400 nm which overlaps with the upper end of the ultraviolet (UV) A.This range is visible as purple light but well known as UV.There are two contradictions in this matter. People try to avoid UV rays for example the sunscreen use and eyeglasses protective[20], but at the same time, this wavelength function to myopia control.

Smith et al reported a reduction in monkeys myopia due to exposed by the green wavelength of 570 nm. The purple ray hypothesis is supported by animal studies with possible mechanisms and human clinical observations, which provide valuable practical information for myopia control[21]. Short-wavelength UV rays such as UVB are risk factors for skin cancer, pterygium, and cataract. People doing their activities indoor tend to avoid UV rays, use non-transparent windows, glasses, CLs and UV-protected IOLs. and less violet light emission[22]. In the other hand, people also need sunlight for prevention on myopia risk.

Parental myopia not only increases the incidence, but also plays a significant role in the progression in myopia. Parental myopia can be both a hereditary and environmental cause. Children with myopic parents tend to spend less time outdoors and do more near tasks. However, myopia progression can decrease significantly if children with both myopic parents spend more time outside. A longer number of hours in the sun is a protective measure, and close proximity to close work and duration for reading are worsening factors for myopia[23].

CONCLUSION

Giving vitamin D supplementation at 400 IU per day and sun exposure to junior high school students for 12 weeks increased serum 25-hydroxyvitamin D higher than sun exposure or supplementation separately. There is a significant difference in the lower myopia in the right eye of students who received supplementation and sun exposure. while the significant difference of lower myopia in the left eye for students who received supplementation or sun exposure separately.

Giving vitamin D supplementation and sun exposure to junior high school students could inhibit the progression of myopia. This finding need to be followed up with larger population. and also could be used as a evidence for health policy regarding on sun exposure and vitamin D supplementation as a prevention on myopia progressivity.

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