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Comparison of Micronutrient Intake among Students with and without Computer Vision Syndrome

Perbandingan Asupan Mikronutrien pada Mahasiswa dengan dan tanpa Computer Vision Syndrome

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ABSTRACT

Background: During the COVID-19 pandemic, the risk of computer vision syndrome (CVS) increased due to the prolonged use of digital devices. According to a study in 2018, the adult population in Indonesia suffered from micronutrient deficiency which is essential for the anatomy and physiology of the eye.
Objectives: This study aims to compare the micronutrient intake among students with and without CVS.
Methods: This study used a cross-sectional design. The data were collected online from 34 students of the Nutritional Science Program, Faculty of Health Sciences, Universitas Pembangunan Nasional "Veteran" Jakarta using 24-hour dietary recalls and questionnaires. The data collection was repeated four times. The diagnosis of CVS was established using the Computer Vision Syndrome Questionnaire (CVS-Q) which consists of 16 questions about the frequency and intensity of each symptom. The micronutrient intake was analyzed using an application, namely NutriSurvey 2007. A univariate analysis was carried out to describe the characteristics of the variables. An unpaired t-test or Mann-Whitney test was carried out to test the hypothesis about the difference in micronutrient intake between the non-CVS group and the CVS group.
Results: From a total of 34 subjects, 22 subjects (64.7%) had CVS, most of whom suffered from micronutrient deficiency. The results showed no significant difference in subject characteristics and computer usage between the CVS group and the non-CVS group ($p > 0.05$). The two groups that showed no significant difference in micronutrient intake included Fe, Mg, Cu, vitamin E, vitamin A, retinol, vitamin C, and omega-3 ($p > 0.05$). However, the results of unpaired t-test showed a significant difference in Zn intake between the two groups ($p = 0.036$; CI = 0.125-2.716).
Conclusions: Zn intake plays an important role in preventing CVS. Further research on the benefits of Zn supplementation in preventing CVS is necessary.

INTRODUCTION

During the COVID-19 pandemic, the prolonged use of digital devices for various purposes, such as education, communication, and recreation, mostly exceeded six hours per day[1]. This has resulted in an increased risk of computer vision syndrome (CVS), which refers to symptoms affecting the eyes and vision due to prolonged use of digital devices such as computers, smartphones, and tablets[2].

Symptoms of CVS include itchy eyes, burning eyes, foreign body sensation in the eyes, excessive blinking, watery eyes, red eyes, heavy eyelids, dry eyes, eye pain, blurred vision, double vision, inability to focus on nearby objects, light sensitivity, seeing halos around lights, worsening vision, and headache[3]. These symptoms are temporary and will disappear if the use of digital devices is reduced. If prevention measures are not taken, the symptoms of CVS can persist and worsen[2]. According to research, the global prevalence of CVS among students is estimated at 89.9%, with over 70% of students suffering from low productivity due to the symptoms of CVS[5].

Engaging in activities using digital devices decreases the blink reflex, leading to increased tear evaporation and tear film instability[6]. Decreased blink reflex and dry eyes are often associated with symptoms

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of asthenopia (eye fatigue), light sensitivity, and inability to focus on nearby objects (accommodation)[7].

Research shows that omega-3 fatty acids (O3FAs) can treat computer users' eye problems. A study involving 220 subjects who used computers for more than three hours per day was conducted by administering two capsules of omega-3 containing eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). After three months, improvements were observed based on some symptoms of dry eyes, cellular morphology, goblet cell density (Nelson grading), tear production (Schirmer's test), and tear film stability (TBUT scores). Conversely, no improvements were observed in the placebo group who received olive oil[6].

The prolonged use of digital devices also increases exposure to blue light, which has a short wavelength of 415-455 nm and produces high energy. Blue light exposure is known to cause instability in the tear film layers, enhance the generation of reactive oxygen species (ROS), and stimulate the production of pro-inflammatory cytokine IL-1β[8,9]. Research shows that the levels of pro-inflammatory cytokines IL-1β and IL-6 in the tears of female computer users are higher compared to non-computer users[10]. Pro-inflammatory cytokines such as IL-1β, TNF-α, IL-6, chemokines, and MMP are known to damage and reduce the number of goblet cells in the conjunctiva, leading to tear film instability and excessive tear evaporation[11].

Oxidative stress can occur in various structures of the eyes, particularly on the ocular surface (cornea and sclera), lens, retina, and retinal pigment epithelium (RPE). These eye structures contain enzymatic antioxidants such as superoxide dismutase (SOD), glutathione peroxidase (GPX), catalase (CAT), and metallothionein (MTs), as well as non-enzymatic antioxidants such as vitamin A, vitamin E, vitamin C, and glutathione. The antioxidant enzymes SOD_1 and SOD_3 use copper (Cu) and zinc (Zn) as cofactors[12]. These antioxidants function to protect the eye from oxidative stress, apoptosis, mitochondrial dysfunction, and inflammation[13].

Micronutrients function as antioxidants and play a role in other aspects of vision structure and function. Vitamin A exists in the eyes in retinol, retinal, retinoic acid, retinyl palmitate, and retinoids. Retinoic acid is known to be involved in ocular growth, while vitamin A in the retina is responsible for the light response. During phototransduction, vitamin A undergoes isomerization from 11-cis retinal to all-trans-retinal in the outer segment of photoreceptors[14]. The precursor of vitamin A, namely β-carotene, is known to play an important role in vision. The lens and retina contain a high concentration of carotenoids such as lutein, zeaxanthin, and mesozeaxanthin, particularly in the macula lutea. These carotenoids act as antioxidants that protect the lens and retina from damage. In addition to their antioxidant properties, these three carotenoids function as blue light filters, preventing phototoxicity in the outer segment of photoreceptors[13,15]. A study administering carotenoid supplements (lutein, zeaxanthin, and mesozeaxanthin) at a daily dosage of 24 mg for six months to healthy adults with a daily screen time of six hours showed an increase in macular pigment density. The increase correlates with improved visual function and reduced symptoms of eye fatigue, eye strain, blurred vision, headaches, and neck tension[15].

Ions such as iron (Fe), zinc (Zn), and copper (Cu) are essential for the structure and physiology of the retina. Zinc ions act as antioxidants and are necessary for rhodopsin's visual cycle, stability, and functioning. Copper ions are required for the functioning of rhodopsin and ganglion cells. Iron ions play a role in the visual cycle by activating RPE65, an enzyme that converts all-trans retinyl ester to 11-cis retinol. In addition, iron is involved in the process of phototransduction by activating guanylate cyclase, activating aconitase for glutamate synthesis, contributing to the formation of photoreceptor disc membranes, and serving as a cofactor for guanylate cyclase, an enzyme involved in the resynthesis of cyclic guanosine monophosphate (GMP) in the dark state[16].

Several studies have shown magnesium (Mg) ions are required for normal metabolism and ion balance in ocular tissues. Magnesium is an important cofactor in cellular metabolism for ATP production, intracellular ion balance, and the function and structure of ocular tissues[17]. It acts as a cofactor for Na^{+}/K^{+} ATPase, which plays a role in the active transport of Na^{+} ions out of cells in exchange for K^{+} ions. Magnesium deficiency leads to the accumulation of intracellular Na^{+} and the release of mitochondrial Ca^{2+} ions. The accumulation of these ions causes cell swelling, leading to apoptosis of retinal ganglion cells. In addition, magnesium ions restrict calcium influx, inhibit glutamate release, and protect retinal ganglion cells[18]. Magnesium is also required for the biosynthesis of reduced glutathione (GSH), SOD, and catalase[17]. Oxidative stress in the eyes can increase the production of nitric oxide (NO), which damages retinal ganglion cells. It can also increase the production of endothelin-1 (ET-1), which inhibits blood flow to the optic fiber and activates astrocytes. Activated astrocytes generate NO, free radicals, and ET-1, creating a destructive cycle. Magnesium acts as an antioxidant that inhibits astrocyte activation[19].

According to a study in 2018, the adult population in Indonesia suffered from micronutrient deficiency, including Fe (32.4%), Zn (35.5%), vitamin A (44.8%), and vitamin C (71.4%)[20]. Based on these findings, this study was conducted to investigate the difference in micronutrient intake between students with and without CVS during online learning, which was implemented during the COVID-19 pandemic. This study aims to compare the micronutrient intakes that involve vitamin A, retinol, vitamin C, vitamin E, Fe, Zn, Mg, Cu, and omega-3, playing an important role in visual function between students with and without CVS. The research subjects of this study were selected from the Nutritional Science Program, Faculty of Health Sciences, Universitas Pembangunan Nasional "Veteran" Jakarta, to ensure the validity of the dietary recall data, although they were collected online.

METHODS

This cross-sectional study was conducted from March to October 2022. The research population was students of the Nutritional Science Program, Faculty of Health Sciences, Universitas Pembangunan Nasional "Veteran" Jakarta. The sample size was calculated using

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the formula for testing the difference in proportions between two unpaired groups of categorical variables (α = 5%, β = 80%, P_1 = 0.433, P_2 = 0.866). The values of P_1 and P_2 were obtained from a previous study[21]. The calculation resulted in a minimum sample size of 36 people. An additional 10% was added to the calculated sample size to account for potential dropouts, resulting in a final sample size of 40 people.

The inclusion criteria for the research subjects consisted of four criteria: active university students, using a laptop/smartphone for a minimum of two hours per day, having normal visual acuity (emmetropia) or wearing glasses with a maximum of -3.00 diopters (mild myopia), and willing to participate in the study. Students who were taking food supplements had a history of eye surgery or abnormalities, had a history of eye allergies, used contact lenses or eye drops, were taking medications (antidepressants, antihistamines, beta-blockers, corticosteroids, diuretics, or hormone replacement therapy), had a history of diseases (diabetes, Sjogren's disease, rheumatoid arthritis, or thyroid dysfunction) were excluded from the study.

This study obtained ethical clearance certificate number 49/III/2022/KEPK from the Health Research Ethics Committee of Universitas Pembangunan Nasional "Veteran" Jakarta. The subjects were instructed to complete a demographic and behavioral questionnaire using a computer to collect data on micronutrient intakes. Before data collection, the researchers conducted an online meeting to explain the data collection procedures and clarify the meaning of each questionnaire item to the subjects. The CVS, demographic, and behavioral questionnaires were created in Google Forms and shared with the subjects via Google Drive.

The average daily micronutrient intake data were collected using the 24-hour dietary recall survey method. The subjects were instructed to complete the dietary recall form (self-report) four times[22] on Monday, Tuesday, Thursday, and Friday. The data on 24-hour dietary recall were analyzed using a NutriSurvey 2007 application developed by Dr. Juergen Erhardt, which included a list of Indonesian foods based on the 2019 Indonesian Food Composition Table. Other food and beverage data were adjusted according to the intake of the subjects. Initially, this study included 45 subjects who met the inclusion criteria. However, nine subjects dropped out because they did not meet the daily requirement of 1100-1600 calories. This was due to the subjects' inaccurate recording of food and beverage intakes in the 24-hour dietary recall form. As a result, only 36 subjects, consisting of 34 females and 2 males, were included. Considering that the recommended dietary allowance (RDA) is influenced by sex, only the data from female subjects were analyzed.

The computer vision syndrome (CVS) diagnosis was established using the Computer Vision Syndrome Questionnaire (CVS-Q), which consisted of 16 questions about the frequency and intensity of each symptom. The frequency category was divided into three levels: a score of 0 if the symptom was not experienced, a score of 1 if the symptom was experienced once a week, and a score of 2 if the symptom was experienced between two and three times a week or almost every day. Meanwhile, the intensity category was divided into two levels: moderate with a score of 1, and severe with a score of 2. Each symptom was assigned a score calculated by multiplying the frequency and intensity scores, and the scores of all symptoms were summed up. The subject was diagnosed with CVS if the total score was $\geq$ 6. Conversely, if the total score was $<$ 6, the subject was not diagnosed with CVS. This study found that the CVS-Q was valid and reliable, with a sensitivity of 75% and a specificity of 70%[3]. The CVS-Q was translated into Indonesian and tested on 30 students in this study. The questionnaire was valid and reliable, with Cronbach's alpha of 0.740.

The data were analyzed using statistical software, namely SPSS. The univariate analysis was carried out to describe the characteristics of the variables. The Shapiro-Wilk test was carried out to test the data distribution. Subsequently, another statistical test was carried out to compare the characteristics of the subjects and their computer usage behavior between the non-CVS group and the CVS group. The independent t-test or Mann-Whitney U test was conducted to test the hypothesis about the difference in micronutrient intake between the non-CVS and CVS groups.

RESULTS AND DISCUSSION

The results of the data analysis showed that from a total of 34 subjects, 22 subjects (64.7%) experienced CVS. Similar findings were found in a study on 300 medical students in Riyadh, Saudi Arabia, which showed a high percentage of subjects experiencing the symptoms of CVS. In that study, 38% of the subjects experienced more severe symptoms, and 48% experienced symptoms with a higher frequency during the COVID-19 pandemic than before[23]. Therefore, preventive measures should address this issue and prevent CVS from persisting or worsening.

Several individual factors can increase the risk of developing CVS. Research shows that the prevalence of CVS increases with age, with the lowest prevalence found in individuals under 20 years old and the highest prevalence found in individuals aged 40 years or older[24]. Another study suggested that the duration of computer usage by students is directly proportional to the risk of CVS[25]. Furthermore, uncorrected refractive errors can trigger increased accommodation to compensate for blurred vision, significantly increasing the symptoms of CVS[26]. Another study suggested that subjects who used corrective lenses for refractive errors (glasses) were at a higher risk of experiencing CVS compared to those who did not wear glasses[27]. In this study, the results of the Mann-Whitney test showed no differences in age and duration of computer and smartphone usage between the non-CVS group and the CVS group. The results of the Chi-square test also showed no differences in refractive errors of the right and left eyes between the two groups ($p > 0.05$) (Table 1). Therefore, it can be concluded that individual factors did not influence the findings of this study.

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Table 1. Comparison of age, duration of digital device usage, and visual acuity among students of the Nutritional Science Program, Faculty of Health Sciences, Universitas Pembangunan Nasional "Veteran" Jakarta with and without computer vision syndrome

Characteristics	Non-CVS group	CVS group	p-value
Age (years)	20 (18-21)	20 (19-22)	0.704[a]
Computer usage (hours)	8 (2-10)	8 (3-11)	0.680[a]
Smartphone usage (hours)	7 (2-12)	6 (2-15)	0.689[a]
Refractive error (right eye)			
None (emmetropia)	8 (44.4%)	10 (55.6%)	0.410[b]
Near-sightedness (myopia)	4 (25.0%)	12 (75%)	
Refractive error (left eye)			
None (emmetropia)	9 (47.4%)	10 (52.6%)	0.195[b]
Near-sightedness (myopia)	3 (20.0%)	12 (80.0%)	

CVS = computer vision syndrome; *statistically significant at $p < 0.05$
[a]Mann-Whitney test, [b]Chi-square exact test

Several factors that can prevent or reduce the symptoms of CVS include lighting, comfortable seating, monitor position, and rest breaks. Some recommended practices to prevent or reduce the symptoms of CVS include using the computer at a distance of 45-70 cm with the monitor positioned 15-20 degrees below eye level, ensuring sufficient room lighting and monitor brightness, minimizing glare on the monitor, maintaining an upright sitting position in a comfortable chair, implementing the 20-20-20 rule (taking a 20-second break to look at something 20 feet away every 20 minutes), taking a 15-minute break after using the computer for two hours, and consciously blinking the eyes[2]. This study showed no differences in computer usage behavior between the non-CVS and CVS groups (Table 2). Therefore, it can be concluded that the findings of this study were not influenced by computer usage behavior.

Table 2. Computer usage behavior among students of the Nutritional Science Program, Faculty of Health Sciences, Universitas Pembangunan Nasional "Veteran" Jakarta with and without computer vision syndrome

Behavior	Non-CVS group	CVS group	p-value
Using a comfortable chair			
Never	4 (57.1%)	3 (4.9%)	
Sometimes	5 (26.3%)	14 (73.7%)	0.352[a]
Often	3 (37.5%)	5 (62.5%)	
Sitting with ergonomic posture			
Never	2 (50%)	2 (50%)	
Sometimes	6 (30%)	14 (70%)	0.669[a]
Often	4 (40%)	6 (60%)	
The distance from the eyes to the monitor is 60-70 cm			
Never	0 (0%)	1 (100%)	
Sometimes	5 (29.4%)	12 (70.6%)	0.664[a]
Often	7 (43.8%)	9 (56.3%)	
The monitor is positioned below eye level			
Never	1 (25%)	3 (75%)	
Sometimes	2 (15.4%)	11 (84.6%)	0.098[a]
Often	9 (52.9%)	8 (47.1%)	
Implementing the 20-20-20 rule			
Never	4 (25%)	12 (75%)	
Sometimes	8 (47.1%)	9 (52.9%)	0.346[a]
Often	0 (0%)	1 (100%)	
Taking a break for a minimum of 15 minutes every two hours			
Never	1 (20%)	4 (80%)	
Sometimes	6 (31.6%)	13 (68.4%)	0.607[a]
Often	5 (50%)	5 (50%)	
Consciously blinking the eyes			
Never	2 (50%)	2 (50%)	
Sometimes	5 (35.7%)	9 (64.3%)	0.883[a]
Often	5 (31.3%)	11 (68.8%)	
The room is well-lit			
Never	1 (50%)	1 (50%)	
Sometimes	2 (28.6%)	5 (71.4%)	1.000[a]
Often	9 (36%)	16 (64%)	
The screen brightness is optimal			

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Behavior	Non-CVS group	CVS group	p-value
Never	0 (0%)	1 (100%)	0.816[a]
Sometimes	6 (31.6%)	13 (68.4%)	
Often	6 (42.9%)	8 (57.1%)	
Minimal glare on the monitor			
Never	0 (0%)	2 (100%)	
Sometimes	9 (45%)	11 (55%)	0.421[a]
Often	3 (25%)	9 (75%)	

CVS = computer vision syndrome; *statistically significant at $p < 0.05$
[a]Chi-square exact test

The average micronutrient intake of the subjects was compared with the recommended dietary allowance (RDA) for the Indonesian population based on the Regulation of Indonesian Ministry of Health No. 28 of 2019[28]. This study showed that many subjects suffered from micronutrient deficiency, which is important for visual structure and function (Figure 1). This could be due to inadequate consumption of fruits and vegetables. In this study, the average (minimum-maximum) intake of vegetables was found to be 38.1 (0-76.3) g/day, while the intake of fruits was 40.4 (0-187.5) g/day. These findings are consistent with the 2018 Indonesian Basic Health Research (RISKESDAS) data, which showed that 95.5% of the Indonesian population inadequately consumed fruits and vegetables[29]. Another study suggested that the modern cafeteria and vegetarian diet contribute to the micronutrient deficiency of vitamin A[30]. Considering that many of the subjects suffered from micronutrient deficiency, it is necessary to educate them about the importance of a diet that supports visual structure and function in the present era of extensive usage of digital devices.

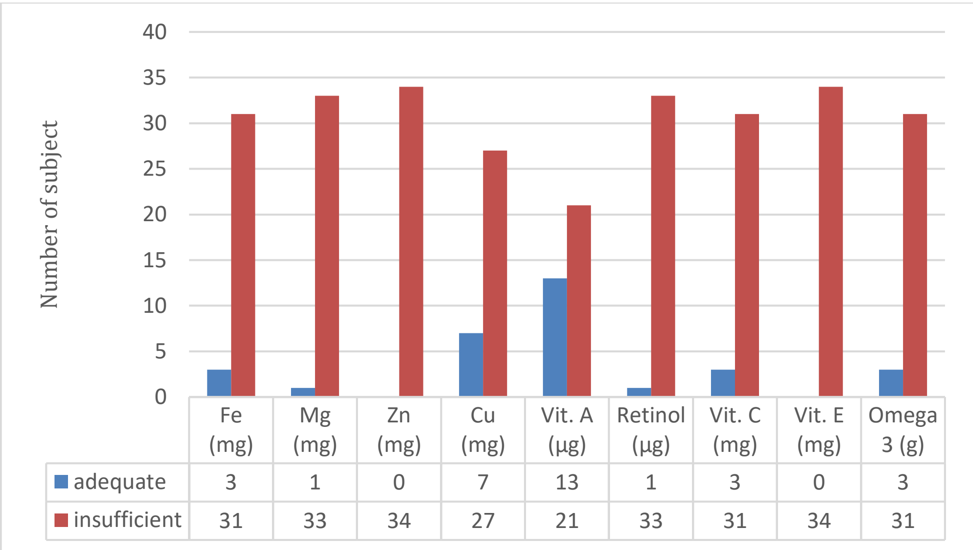

Figure 1. Micronutrient intakes of subjects based on recommended dietary allowance

The results of this study showed no significant differences in the micronutrient intake (vitamin A, retinol, vitamin C, vitamin E, omega-3, Fe, Mg, and Cu) between the two groups ($p > 0.05$). However, the Zn intake in the CVS group was lower compared to the non-CVS group ($p = 0.036$; CI = 0.125-2.716) (Table 3). These findings are consistent with several other studies that suggested the important role of Zn in maintaining ocular function, with ocular tissues having a higher concentration of Zn compared to other tissues[31].

Table 3. Comparison of micronutrient intakes among students of the Nutritional Science Program, Faculty of Health Sciences, Universitas Pembangunan Nasional "Veteran" Jakarta with and without computer vision syndrome

Micronutrient	Non-CVS group	CVS group	p-value
Fe (mg)	6.43 ± 2.37	5.09 ± 1.85	0.079[a]
Mg (mg)	159.8 (96.6 -652.9)	145.4 (74.2 – 260.9)	0.505[b]
Zn (mg)	5.48 ± 1.97	4.06 ± 0.96	0.034[a]*
Cu (mg)	0.65 (0.45-3.18)	0.73 (0.25-1.53)	0.678[b]
Vitamin A (µg)	722.1 (378.6 – 2068.6)	669.1 (1766 – 1347.0)	0.773[b]
Retinol (µg)	153.5 (37.9 – 1337.9)	83.9 (14.7 – 673.0)	0.056[b]
Vitamin C (mg)	20.1 (5.05 – 97.1)	21.8 (2,5 –165.2)	0.914[b]
Vitamin E (mg)	3.81 ± 1.16	3.12 ± 1.25	0.122[a]
Omega-3 (g)	0.125 (0.00 – 1.28)	0.030 (0.00 – 139.7)	0.098[b]

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CVS = computer vision syndrome; *statistically significant at $p < 0.05$
[a]Unpaired t-test, [b]Mann-Whitney test

Ocular tissues contain a significant amount of the metallothionein (MT) antioxidant. Metallothionein plays a role in capturing and neutralizing free radicals through redox reactions by binding and releasing zinc. The Zn-MT redox cycle is an antioxidant defense system on the ocular surface, lens, retina, and retinal pigment epithelium. Metallothionein captures and neutralizes free radicals using its sulfur-containing ligand cysteine, which acts as a donor of Zn ions. Under oxidized conditions, Zn bound to MT is released, forming MT-disulfide (thionine). This process is enhanced by free radicals such as nitric oxide, ROS, and glutathione disulfide (GSSG). The released zinc can be stored in zincosomes or transferred to other proteins capable of binding zinc. MT-disulfide is unstable and can undergo degradation. When the ratio of glutathione/glutathione disulfide (GSH/GSSG) is reduced, MT disulfide is converted to MT-thiol (thionine), a process catalyzed by selenium. Zn–MT can be regenerated in available Zn (Figure 2)[12]. Additionally, zinc n neutralizes free radicals through glutathione as it is a cofactor for glutathione peroxidase[32].

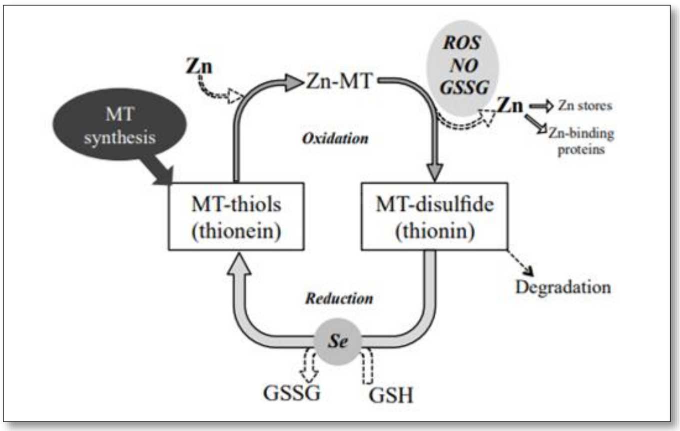

Figure 2. MT-Zn redox cycle[12]

The results of in-vitro studies showed that Zn can reduce the transcription factor NF-κB and pro-inflammatory genes TNF-α, IL-6, IL-8, and IL-1, as well as the expression of A20 and PPAR-γ genes that inhibit the activation of NF-κB. Therefore, it can be concluded that Zn is a potent anti-inflammatory agent[32]. Zinc also has several other functions, including its interaction with taurine and vitamin A in the retina and retinal pigment epithelium, modification of photoreceptor membranes, regulation of the light-rhodopsin reaction, and modulation of synaptic transmission (Figure 3)[31].

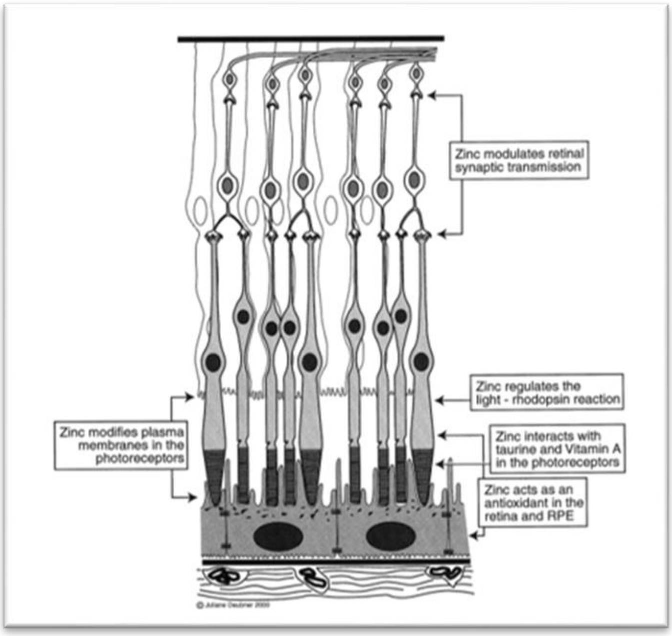

Figure 3. The function of Zn in the retina and retinal pigment epithelium[31]

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In addition, zinc is required for several functions: (1) the functioning of retinol dehydrogenase (RD), an enzyme that plays a role in processing retinol in the visual cycle; (2) the functioning of phosphodiesterase (PDE), which catalyzes the hydrolysis of cyclic guanosine monophosphate (cGMP), leading to the closure of cGMP-gated channels and inhibiting the influx of Na^{2+} and Ca^{2+}; (3) binding to the outer membrane of rod cell segments, a protein that acts in the deactivation of rhodopsin after light stimulation of rhodopsin, and (4) the stability and functioning of rhodopsin (Figure 4)[16]. The results of an in-vivo study on *Raja erinacea* showed that Zn functions protect retinal neurons from glutamate toxicity by inhibiting the influx of Ca^{2+} ions[33].

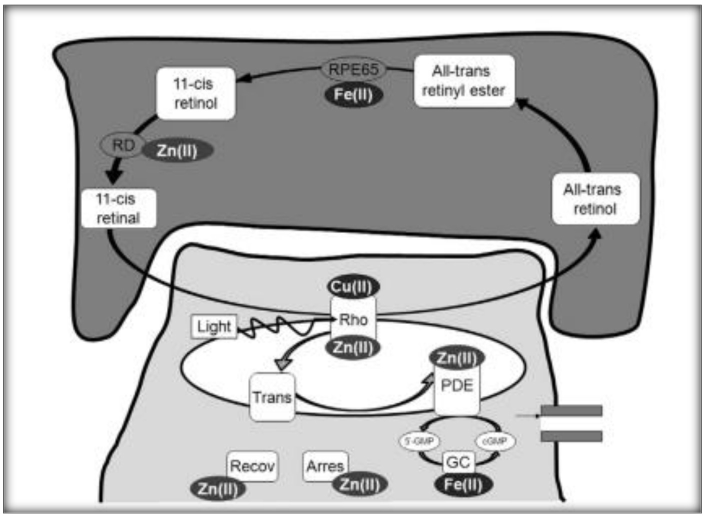

Figure 4. The function of Fe, Zn, and Cu ions in the photoreceptors and retinal pigment epithelium[16]

The results of a preliminary study suggested that supplementation with Zn extract, L-carnitine, elderberry extract, black currant, and eleutherococcus for a month significantly reduced the symptoms of CVS scores in 15 workers using video display terminal (VDT)[7]. Another study showed that supplementation with micronutrient pills containing Zn, Cu, Mn, Se, vitamin A, vitamin C, vitamin E, tyrosine, cysteine, glutathione, DHA, EPA, and docosapentaenoic acid (DPA) for three months in female computer users reduced the levels of IL-1β and IL-6 inflammatory cytokines in tears, as well as alleviated symptoms of dry eyes, burning eyes, heavy eyes, and blurred vision[10]. Both findings suggested the potential of certain micronutrients in treating CVS-related problems.

This study is a preliminary study that compares the micronutrient intake between students with and without CVS. This study has several limitations. Firstly, the findings cannot be generalized to the general population as the research subjects were limited to female subjects. Secondly, the data on micronutrient intake were collected online and self-reported by the subjects, which may lead to incomplete or inaccurate responses. To overcome this limitation, the researchers selected the research subjects from students of the Nutritional Science Program, explained the research procedures and the meaning of each questionnaire item, and provided the contact number of the researchers if the subjects had any questions related to the study. Thirdly, a previous study suggested that conducting four repeated dietary recalls is sufficient to capture micronutrient intake[22]. However, it would be more accurate if the dietary recalls were conducted seven times to align with the CVS questionnaire data reflecting the subjects' vision-related problems over the past week.

CONCLUSIONS

In this study, 22 out of 34 subjects (64.7%) experienced CVS. The findings suggested that the micronutrient intake of the subjects, namely vitamin A, retinol, vitamin C, vitamin E, Fe, Mg, Cu, and omega-3, was insufficient. This study found no significant difference in the micronutrient intake between the CVS and non-CVS groups, except for Zn, which was lower in the CVS group than the non-CVS group. Given that Zn has various functions in vision and is highly concentrated in ocular tissue, it can be concluded that Zn intake plays an important role in preventing CVS. However, further research is necessary to explore the benefits of Zn supplementation in preventing CVS.

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Conflict of Interest and Funding Disclosure

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