·Investigation·

Prevalence of asthenopia and its risk factors in Chinese college students

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Abstract

• AIM: To determine the prevalence of asthenopia and identify any associated risk factors in the college students in Xi´an, China.

• METHODS: From April to September 2012, 1 500 students from five universities in Xi´an were selected according to a multi-stage stratified cluster sampling method. Data on demographic features, lifestyle or dietary habits, health status, living environment conditions, sleep and mental status, and asthenopia symptoms were collected through a self-administered validated questionnaire. Univariate logistic regression and multivariate logistic regression analysis modified by the factor analysis were performed to evaluate risk factors for asthenopia.

• RESULTS: Fifty-seven percent of the college students complained of asthenopia. Statistically significant risk factors for asthenopia in the univariate analysis included 13 variables. Multivariate analysis revealed a significant relationship between the use of computer and asthenopia (OR 1.21, 95% CI: 1.09 to 1.35). Good sleep and mental status (OR 0.86, 95% CI: 0.76 to 0.97), good living environment conditions (OR 0.67, 95% CI: 0.60 to 0.76), and high intake of green leafy vegetables (OR 0.89, 95% CI: 0.80 to 0.98) were found to be strong predictors of decreasing the occurrence of asthenopia complaints.

• CONCLUSION: Asthenopia symptom appeares to be common among college students; and it is strongly associated with computer use, psychosocial state, environment conditions and dietary habits, suggesting that additional studies are warranted to verify these risk factors and establish prevention guidelines, especially for college students.

• **KEYWORDS:** asthenopia; risk factor; epidemiological feature; college student

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INTRODUCTION

Asthenopia includes visual discomfort symptoms such as impaired reading performance, light sensitivity, blurred vision, diplopia, and perceptual distortions [1]. It has become a significant public health problem [2]. With the change of lifestyle and the spread of personal computers, increasing rates of such complaints have been reported in various industries [3]. These asthenopia symptoms can be severe enough to limit personal activities and further result in potentially speeding up the development of age-related eye diseases [4]. Therefore, identifying risk factors of asthenopia is of great importance to improve visual function and decrease the risk of visual fatigue. Some epidemiologic studies have found that asthenopia was possibly associated with systemic symptom, psychological states and environmental factors, whereas still others have reported inconsistent results [5,6]. Moreover, until recently little information is available regarding the asthenopia with risk factors among the college students. Most of them have been experiencing the processing of functional maturation of the visual system in this time frame, which makes ocular tissue of college students more sensitive to the environmental change compared with other populations [7]. The decrease in visual fatigue among college students might lead to an important benefit to promote next generation of their career and health. Therefore, we conducted a cross-sectional study to examine the relationships between visual fatigue and the related factors among college students from five universities in Xi'an, China.

SUBJECTS AND METHODS

Subjects Students aged 18 to 30 years were selected in Xi'an, Shaanxi Province, according to a multi-stage stratified cluster sampling method. In the first stage, the five

universities were selected from Xi'an. In the second stage, 30 to 40 student dormitories of each grade were chosen from each selected university based on lists of the dormitory schedule of different grades. About 700 student dormitories were selected. Finally, 1 to 3 students from each selected dormitories were chosen as subjects of the study. A total of 1 500 students were enrolled in the study.

Methods This was a cross-sectional study. The questionnaire was developed by an expert panel using the nominal group technique. The questionnaire was piloted on 40 subjects and the results suggested that this questionnaire had good reliability and validity.

Information on demographic features, lifestyle or dietary habits, perceived health status, the hygiene of using eye, living environment conditions, and sleep and mental status were requested on the questionnaire. Doing exercises hours were categorized into three groups: <0.5h/week, 0.5-3.5h/week, and >3.5h/week. Body mass indexes (BMI) were categorized into three groups: <24kg/m^2, 24-27.9kg/m^2, and ≥28kg/m^2. Daily computer use hours were categorized into four groups: <1h, 1-3h, 3-5h and >5h. Asthenopia symptoms were adopted from the items of the subjective symptom checklist: eye pain, dry eyes, eye swelling, blurred vision, diplopia, foreign body sensation, photophobia, tearing, decreased visual acuity, and difficulty in sustaining visual operations. Asthenopia was defined as the presence of one or more these subjective symptoms [8,9]. The interview was conducted face-to-face between interviewers and interviewees. The strict supervision process had been found to ensure the quality of the investigation. The participants were assured that they would remain anonymous.

Statistical Analysis All data of questionnaires were uploaded into a computerized database after checked for accuracy by two investigators independently. Differences in demographic data between the cases and controls were compared using the χ^2 test for categorical data. Odds ratios (OR) and 95% confidence intervals (95%CI) were calculated by using univariate logistic regression analysis to quantify the associations between asthenopia and its relevant variables. Factor analysis was used to identify the structure underlying significant variables and to estimate scores to measure latent factors *via* principal component analysis [10]. The factors are rotated by an orthogonal transformation and the factors with eigenvalues greater than 1.0 were extracted. The relationships between the occurrence of visual fatigue and the scores of factors were assessed by multiple linear regression models. A 2-tailed P value of less than 0.05 was considered significant. All analysis were performed using the SPSS statistical software (version 12.0, SPSS Inc., Chicago, IL, USA).

RESULTS

Epidemiological Feature of Asthenopia Of the 1 500 students who responded to the survey, 31(2.1%) did not complete the item. The participants aged from 17 to 28 years, their average age was 21.4 years, and 58.7% are males. Of the remaining 1 469 (97.9%) students, 838 (57.0%) reported that they had asthenopia symptoms (Table 1). The results showed that the difference between males and females was not significant (P>0.05). Smoking, drinking and doing exercises were not markedly different between cases and non-cases defined by the asthenopia symptoms. The comparison between them revealed significant difference of BMI (P=0.02).

Table 1 The comparison of general characteristics of subjects with and without asthenopia in universities

Parameters	Case (n=838)	Normal (n=631)	[1]P
Gender, n (%)			
M	492 (58.7)	370 (58.6)	0.98
F	346 (41.3)	261 (41.4)	
[2]BMI, n (%)			
<24kg/m^2	745 (88.9)	580 (91.9)	
24-27.9kg/m^2	79 (9.4)	49 (7.8)	0.02
≥28kg/m^2	14 (1.7)	2 (0.3)	
Smoking, n (%)			
Yes	91 (10.9)	68 (10.8)	0.96
No	747 (89.1)	563 (89.2)	
Drinking, n (%)			
Yes	137 (16.3)	111 (17.6)	0.53
No	701 (83.7)	520 (82.4)	
Doing exercises, n (%)			
never	229 (27.3)	189 (29.9)	
<3.5h/week	423 (50.5)	280 (44.4)	0.06
≥3.5h/week	186 (22.2)	162 (25.7)	

[1]Based on χ^2 test. [2]BMI: Body mass index, calculated as weight in kilograms divided by height in square meters.

Table 2 Simple logistic regression for the factors related to asthenopia

Variable	OR (95%CI)	P
Intake of green leafy vegetables	0.65 (0.44, 0.95)	0.028
Daily computer usage	4.22 (3.60, 4.95)	<0.001
Cathode ray tube computer screen	1.17 (1.06, 1.30)	0.002
Viewing angle of computer screen	1.29 (1.01, 1.65)	0.047
Eye or systemic disease	1.82 (1.06, 3.10)	0.029
Taking medicine	3.54 (1.34, 9.36)	0.011
Indoor temperature	1.90 (1.33, 2.70)	<0.001
Air quality	0.45 (0.31, 0.64)	<0.001
Noise	2.18 (1.55, 3.08)	<0.001
Sleep quality	0.50 (0.36, 0.71)	<0.001
Mental state	0.72 (0.53, 0.98)	0.034
Sense of social identity	0.40 (0.28, 0.57)	<0.001
Family history of eye disease	2.04 (1.27, 3.27)	0.003

Univariate Logistic Regression Analysis The results of univariate logistic regression analysis showed that each variable in Table 2 was significantly associated with the occurrence of asthenopia. Independent protective factors included higher intake of green leafy vegetables (OR 0.65, 95%CI: 0.44 to 0.95), air quality (OR 0.45, 95%CI: 0.31 to 0.64), sleep quality (OR 0.50, 95%CI: 0.36 to 0.71), mental

Table 3 Eigenvalue, contributive rate and cumulative contributive rate for every factor

Parameter	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Eigenvalue	1.57	1.55	1.23	1.22	1.10	1.06
Contributive rate (%)	12.08	11.92	9.49	9.38	8.46	8.12
Cumulative contributive rate (%)	12.08	24.00	33.48	42.86	51.32	59.43

Table 4 Multivariate logistic regression of factor score

Common factor	Dominant variable	Meaning	OR (95%CI)
F1	Daily computer usage, cathode ray tube computer screen, viewing angle of computer screen	Computer use	1.21 (1.09, 1.35)
F2	Sleep quality, mental state, and sense of social identity	Good sleep and mental status	0.86 (0.76, 0.97)
F3	Indoor temperature, air quality, and noise	Good living environment conditions	0.67 (0.60, 0.76)
F4	Eye or systemic disease, and taking medicine	Bad physical state	1.00 (0.89, 1.13)
F5	Intake of green leafy vegetables	Good factor of diets	0.89 (0.80, 0.98)
F6	Family history of eye disease	Family history	0.98 (0.89, 1.08)

state (OR 0.72, 95%CI: 0.53 to 0.98), sense of social identity (OR 0.40, 95% CI: 0.28 to 0.57); and higher occurrence of visual fatigue was associated with daily computer usage (OR 4.22, 95% CI: 3.60 to 4.95), cathode ray tube (CRT) computer screen (OR 1.17, 95%CI: 1.06 to 1.30), viewing angle of computer screen (OR 1.29, 95%CI: 1.01 to 1.65), eye or systemic disease (OR 1.82, 95% CI: 1.06 to 3.10), taking medicine (OR 3.54, 95%CI: 1.34 to 9.36), unsuitable indoor temperature (OR 1.90, 95% CI: 1.33 to 2.70), noise (OR 2.18, 95% CI: 1.55 to 3.08) and family history (OR 2.04, 95% CI: 1.27 to 3.27).

Factor analysis From the factor analysis of the asthenopia symptoms, six factors were extracted (Table 3). The Factor 1 was computer use, consisted of three items, which were daily computer usage, type of computer screen, and viewing angle of computer screen. Factor 2, good sleep and mental status, included sleep quality, mental state, and sense of social identity. Factor 3, good living environment conditions, consisted of three items, which were indoor temperature, air quality and noise. Factor 4, bad physical state, contained eye or systemic disease, and taking medicine. Factor 5, good factor of diets, consisted of intake of green leafy vegetables. Factor 6 was family history of eye disease (Table 4).

Multivariate Logistic Regression Analysis The results of the multivariate logistic regression analysis of factors related to the occurrence of asthenopia are shown in Table 4. The output of the logistic model revealed significant associations between four factors and the occurrence of asthenopia ($P<0.05$). Among the factors, computer use (OR 1.21, 95%CI: 1.09 to 1.35) was a risk factor for the occurrence of asthenopia, whereas protective factors included good sleep and mental status (OR 0.86, 95% CI: 0.76 to 0.97), good living environment conditions (OR 0.67, 95%CI: 0.60 to 0.76), and good factor of diets (OR 0.89, 95%CI: 0.80 to 0.98).

DISCUSSION

Recently, numerous studies have investigated the epidemiological feature of asthenopia, and found the number of people affected by this disease was expected to rise dramatically in the near future [3,11]. Aakre and Doughty [12] assessd the association between self-reported symptoms of asthenopia and video display terminal (VDT) use. The results indicated that the people reporting experiencing some visual symptoms or specific ocular symptoms sometimes were 70.0% and 82.5%, respectively. A similar prevalence rate of eye fatigue was also observed in a study, conducted in operators of call centers [13]. Until recently the study specifically concerning the prevalence and its related risk factors of asthenopia among the college students were still limited. In the current study, our results found that there was a high prevalence of asthenopia of the college students in Xi'an, approaching to 57.0%, which was comparable to those in the workers using VDT reported by previous studies. This finding from this study indicated that college students experienced deterioration in their eye health status. Therefore, it is urgent to identify its risk factors and develop effective strategies for helping to protect against asthenopia and improve visual function in college students.

Our findings provided evidence that multiple factors have the potential to influence the incidence of asthenopia, including psychological state, environment, health status, and dietary and lifestyle habits. Long-time VDT use could gradually damage regulatory function of the eyes and then result in the formation of visual fatigue [14]. Yoshioka *et al* [15] suggested that VDT work of 6h or longer per day was significantly associated with sleep-related symptoms and visual fatigue among Japanese government clerks, even after adjusting for possible confounding factors. Compared with CRT computer screen, higher contrast ratio of liquid crystal display (LCD) resulted in better visual recognition and higher subjective preference, making enhancing worker satisfaction. In addition, the lower reflected light or glare of LCD could bring less harm to the ocular tissue [16]. Moreover, visual and

ocular problems are well known to be associated with awkward postures [17,18]. Our results agreed with the earlier studies and reported a relatively high complaining of visual fatigue for the subjects with poor viewing angle of computer screen. Thus, college students should be advised to pay more attention to a comfortable sitting position and use adjustable chairs.

Under the negative emotions, the stress response of autonomic nervous system deteriorates the endocrine function and thereafter affects the internal environment of eyes, which leads to the aggravation of visual fatigue [19]. We investigated the relation of psycho-mental factors to visual fatigue and found that a good mental state and a sense of social identity exerted beneficial effects for visual fatigue. Our results were consistent with work by Ye *et al* [20], who noted that negative mental status were significantly positively associated with visual abnormalities among Japanese VDT users. Moreover, our finding also was supported by significant association that was found between improvement in the quality of sleep and the decreased risk of visual fatigue. A sufficient amount of sleep is beneficial to relieve asthenopia *via* promoting the functional recovery in ciliary muscle and relaxing eye muscles[21].

Environmental factors had been identified among the several risk factors that could account for the increase in asthenopia incidence. Under hostile environment, decreased tear secretion will affect the stability of the tear film which results in shortening the tear break-up time. Rocha and Debert-Ribeiro [22] noticed that the presence of visual fatigue and mental symptoms were related with poor working and living conditions. Our study also indicated that adverse environmental conditions, including uncomfortable room temperature, poor air quality and noise, are independent risk factors for the incidence in visual fatigue. Consistent with our findings regarding the relationship between noise and asthenopia, Fowler *et al*[23] reported that high-frequency noise applied to healthy speakers would result in significant increases in visual discomfort and/or delayed-onset muscle soreness. Improving environmental conditions, including room temperature, air quality and noise, may have potentially important significance to decrease the risk in visual fatigue. As other important environmental factors, illumination level at the place where VDT is used or where these college students study, may be related with asthenopia. Under inadequate lighting conditions, the students' pupils will continuously dilate, resulting in the occurrence of visual fatigue [24]. However, the results of our study did not observe the significant relationship between illumination level and asthenopia.

Healthy dietary habits had beneficial effects on maintaining normal metabolism and physiological function of eyes. Dark green leafy vegetables are good sources of antioxidants including lutein and zeaxanthin, and the consumption of these carotenoids has been associated with reducing the risk of age-related eye diseases. The combination of evidence suggested these carotenoids play an important role in preventing of visual fatigue and delay the progression of age-related macular degeneration by aiding in the filtering of damaging blue light and quenching reactive oxygen species [25]. Our previous studies had also indicated that the supplementation with lutein and zeaxanthin could improve visual function and relieve asthenopia [26]. Meanwhile, the largest fractions of most eye-protective nutrients (such as vitamin A, lutein and zeaxanthin) are stored in adipose tissue [27]. Thus, higher body fat percentage and BMI may compete with the retina for uptake of these nutrients, resulting in less incorporation in the retina and lower macular pigment. This might explain the reason why subjects with higher BMI had a higher asthenopia prevalence than subjects of normal weight in present study. In addition, we also evaluated the effects of taking nutritional supplementation on the occurrence of asthenopia. However, we did found nutritional supplementation led to a significant benefit, partly due to limited number of students taking nutritional supplements in our population.

Past epidemiologic data have linked history of eye disease and eye injury to risk of visual functional limitations [28]. As most of college students have not experienced these incidents, our results showed that the risk of asthenopia was not significantly influenced by this factor. However, it is also important to promote eye health and prevent certain eye diseases in order to reduce the risk of asthenopia.

Strengths of this study include a multi-stage stratified cluster sampling method design, strict supervision process, and excellent response rates. However, this study also has several limitations. The cross-sectional research design of the current study does not allow inferences of causality about directionality among variables. In addition, this study involved only five universities in Xi'an, which limited the generalizability of the findings.

In conclusion, our results suggested that visual fatigue have become an increasingly important public health problem emerging on college campuses. The observed high asthenopia symptom prevalence is probably related to psychological state, environment, health status, and dietary and lifestyle habits. Therefore, longitudinal studies involving college students are worthwhile to identify the related factors for intervention.

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