• Investigation •

Fruit and vegetable consumption and its relation to risk of asthenopia among Chinese college students

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Abstract
● **AIM: To investigate the associations between fruit and vegetable consumption and risk of asthenopia among Chinese college students.**

● **METHODS: A total of 1022 students were selected from five universities by a multi-stage stratified cluster sampling method. They were surveyed *via* a self-administered questionnaire including socio-demographic features, dietary and lifestyle habits, eye-related symptoms, eye care habits and history of diseases. Ascertainment of asthenopia was based on participants' subjectively reported symptoms. The associations between fruit and vegetable intake with asthenopia risk were assessed using multivariate logistic regression analysis.**

● **RESULTS: There were no significant associations between total fruit and vegetable, total vegetable, or fruit and the risk of asthenopia. Higher intake of dark-green leafy vegetable was likely to be inversely associated with asthenopia risk [odd ratio (OR): 0.60; 95%CI: 0.37-0.97; P_{trend}=0.21] after controlling for nondietary and dietary risk factors. Stratified analysis showed that the inverse association between dark-green leafy vegetable intake and asthenopia risk was limited to participants with suboptimal eyesight (OR: 0.45; 95%CI: 0.25-0.82; P_{trend}=0.05), wearing glasses (OR: 0.35; 95%CI: 0.17-0.72; P_{trend}=0.03) or using computer ≥3h/d (OR: 0.48; 95%CI: 0.25-0.93; P_{trend}=0.08).**

● **CONCLUSION: A higher consumption of dark-green leafy vegetable is associated with a lower asthenopia risk among college students with suboptimal eyesight and poor eye care habits.**

● **KEYWORDS:** asthenopia; fruit; vegetable; epidemiology; college students
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INTRODUCTION

Asthenopia, also known as visual fatigue, often manifest itself *via* various somatic or perceptive symptoms such as headache, sore eyes, eyestrain, tearing, dryness, blurred vision, diplopia, and foreign body sensation[1]. With the dawn of an electronic era, modern society constantly places high demands for prolonged visual task performance, which leads to the increasing prevalence of asthenopia[2]. Gradually worsening eye fatigue may be severe enough to undermine visual health and further impair quality of life, with it already becoming a noticeable public health problem[3].

Previous research has indicated that dietary modifications and nutritional supplements could be advantageous for the prevention and treatment of various eye diseases[4]. Fruit and vegetable are noted as excellent food resources of many favorable nutrients such as lutein, zeaxanthin and vitamins, which have shown protective effects on reducing risks of several age-related eye diseases, such as age-related macular degeneration (AMD) and cataract[5]. However, to our knowledge, available data is limited to provide quantitative evidence for the association between fruit and vegetable intake and asthenopia risk. It is also worth mentioning that college students may be undergoing the process of functional maturation of the visual system, thus their ocular tissue is possibly more sensitive to the effects of various risk factors[6-7]. Asthenopia among them may potentially result in speeding up the development of age-related eye diseases[8]. Hence, it is of significant importance that related factors of asthenopia be identified and effective nutritional measures be started early in college. So far, our previous study has indicated that asthenopia symptom may be associated with computer use, psychosocial state, environment conditions and dietary habits[9]. Rather, various fruit and vegetable subgroups may not be equally associated with the risk of asthenopia[10].

Therefore, the purpose of this study was to examine the association between usual intakes of fruit and vegetable and the risk of asthenopia among college students. It is hypothesized that the consumption of fruit and vegetable reduces the risk of asthenopia.

SUBJECTS AND METHODS

Study Population College students in this cross-sectional study were recruited in Xi'an, Shaanxi Province in 2012, with a multi-stage stratified cluster sampling method. Five universities at different levels were selected in the first stage. Then, participants in each chosen university were stratified by grade, and a weighted sampling scheme was applied to randomly select 30 to 40 student dormitories in each grade. Finally, 1 to 3 students from each selected dormitory were elected as subjects of the study. Among 1500 participants enrolled, 1491 (99.4%) completed the survey. For this analysis, we excluded participants who had a history of nutrients supplementation or diagnoses of systematic chronic diseases or serious eye diseases (such as Graves ophthalmopathy, trachoma, keratitis, conjunctivitis, and hordeolum). After exclusions, a total of 1022 participants were included in the current analysis (Figure 1).

The study was approved by the Institutional Review Board at Xi'an Jiaotong University Health Science Center. The completion of the self-administered questionnaire was considered to imply written informed consent.

Data Collection A self-administered questionnaire based on the research purpose was developed by an expert panel using the nominal group technique, after reviewing relevant literature. The questionnaire used was in Chinese. Questions were designed as close-ended or multiple choices, as appropriate. The items were modified to cover the characteristics of college students, being comprehensible to the participants. Furthermore, to test the validity of the questionnaire, a pilot study was carried out among 40 participants before the launch of formal investigation. The survey questions were revised accordingly for clarity based on the pilot study. The questionnaire took less than 20min to complete on average. The survey was conducted and monitored by trained investigators with strict instruction process, ensuring the quality of this study.

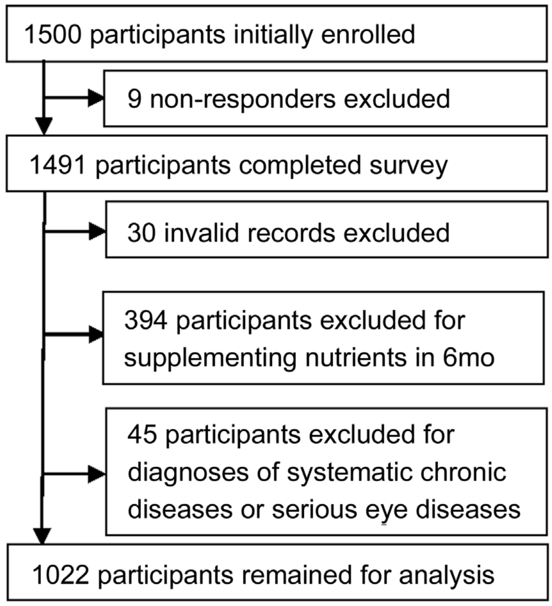

Figure 1 Flow chart of the study population.

Dietary Assessment Participants' habitual diet was assessed using a validated semi-quantitative food frequency questionnaire (SFFQ)[9]. In the SFFQ, we asked the students how often, on average over the previous year, they consumed a defined portion size of each food item, with five possible frequency choices ranging from "almost never" to "2 or more times per day". Vegetable 100 g was used as the serving unit and fruit was defined by numbers. Total fruit and vegetable consumption was calculated by summing the frequency of eating both and then divided into three categories (≤6 servings per week, 7-8 servings per week and ≥9 servings per week). Total vegetable intake was separated into three categories as well (≤3 servings per week, 4-5 servings per week and ≥6 servings per week). Consumption of dark-green leafy vegetable and fruit was categorized into ≤1 serving per week, 2-3 servings per week, and ≥4 servings per week, respectively.

Assessment of Covariates We also obtained self-reported information on socio-demographic features (*e.g.* age, gender, grade, major, household income), lifestyle habits [*e.g.* smoking habits (yes/no), alcohol use (yes/no), physical activity (frequently/occasionally/seldom)], eye care habits [*e.g.* years of wearing glasses (continuous), daily computer use (continuous), viewing angle of computer screen (continuous), using any radiation reducing filter on the monitor (yes/no), taking breaks during the use of computer (yes/no)], perceived health condition (*e.g.* ocular symptoms, systemic symptoms), medical history, a family history of eye diseases (including high myopia, AMD and glaucoma), living environments, sleep quality, mental state and so on. Body mass index (BMI) was calculated as weight in kilograms (kg) divided by squared height in meters (m^2). We divided status of taking exercises into three levels: frequently (three times or more a week), occasionally (once or twice a week) and seldom (never or less than once a week). Refractive status was defined as three categories: emmetropic, myopic, or hyperopic[11]. Eyesight status was dichotomized as optimal and suboptimal eyesight, with the former referring to emmetropia and the latter referring to myopia or hyperopia. A self-evaluated mental state with categories of good, fair and poor was recorded.

Ascertainment of Asthenopia Incident asthenopia was confirmed by asking whether students had ever felt the following subjective symptoms of visual discomfort: ophthalmodynia, dry eyes, eye swelling, eye itching, blurred vision, diplopia, foreign body sensation, photophobia, lacrimation, decreased visual acuity, difficulty in sustaining visual work, and reduced blink frequency. Asthenopia was defined as the presence of one or more above-mentioned symptoms at one or both eyes of participants when reading or doing near work[12-13].

Statistical Analysis Differences in general characteristics of subjects with and without visual fatigue were compared using the Chi-square (χ^2) test for categorical data and *t* test for continuous data. Logistic regression following a hierarchical model was utilized to analyze the associations between asthenopia and consumption of fruit and vegetable and subgroups. Odds ratios (ORs) and their 95% confidence intervals (CIs) were generated to quantify the associations. Model 1 included demographic and lifestyle variables. Model 2 further controlled for visual function estimates and eye hygiene variables. Model 3 was additionally adjusted for dietary factors. The *P*-trend was obtained by entering the categorical variable as continuous variable in the models. We conducted stratified analyses by grade (junior or below *vs* senior or above), sleep quality (good *vs* poor), eyesight (normal *vs* suboptimal), wearing glasses (yes *vs* no) and mean duration of daily computer use (<3h *vs* ≥3h). We estimated the effect of collinearity in the multivariate analysis, and all variable inflation factor values for each independent variable were less than 10. All analyses were conducted using the SPSS statistical software (version 13.0, SPSS Inc., Chicago, IL, USA). A two-tailed *P* value of less than 0.05 was considered statistically significant.

RESULTS

Sample Characteristics The response rate for the investigation was 99.4% with 1491 students completing the survey, among which 1022 were selected under inclusion criteria. The selected characteristics of the study population are summarized in Table 1. About 60.5% of students were male. Their age ranged from 17 to 28y with a mean value of 21.5y. Majority of the students were not overweight or obese and had enough sleep time. Most of them were not in the habit of cigarette smoking or alcohol drinking. More than a quarter of students reported that they were less physically active, taking exercises less than once a week. Over half of the surveyed students reported computer use for three hours or more per day. There were no statistical differences between participants with and without asthenopia in age, gender, BMI, physical exercise, smoking or drinking habits (P>0.05). No differences were found in relation to daily sleep time or daily computer use duration as well (P>0.05). The results also showed that students with asthenopia were more likely to wear glasses, and have a family history of eye diseases than those without asthenopia.

Table 1 The comparison of general characteristics of subjects with and without asthenopia in universities mean±SD; *n* (%)

Parameters	Asthenopia (*n*=577)	Non-asthenopia (*n*=445)	^aP
Age (y)	21.44±1.54	21.48±1.52	0.65
Gender			0.69
Male	352 (61.0)	266 (59.8)	
Female	225 (39.0)	179 (40.2)	
BMI			0.09
<24 kg/m^2	514 (89.1)	408 (91.7)	
24-27.9 kg/m^2	52 (9.0)	35 (7.9)	
≥28 kg/m^2	11 (1.9)	2 (0.4)	
Smoking			0.84
Yes	58 (10.1)	43 (9.7)	
No	519 (89.9)	402 (90.3)	
Drinking			0.41
Yes	87 (15.1)	59 (13.3)	
No	490 (84.9)	386 (86.7)	
Taking exercise[b]			0.34
Frequently	148 (25.6)	118 (26.5)	
Occasionally	284 (49.2)	200 (44.9)	
Seldom	145 (25.1)	127 (28.5)	
Sleep time (h/d)	7.57±1.05	7.57±0.94	0.94
Family history of eye disease			0.05
Yes	38 (6.6)	17 (3.8)	
No	539 (93.4)	428 (96.2)	
Daily computer use			0.46
≥3h	320 (55.5)	257 (57.8)	
<3h	257 (44.5)	188 (42.2)	
Eyesight			0.68
Optimal	163 (28.2)	131 (29.4)	
Sub-optimal	414 (71.8)	314 (70.6)	
Wearing glasses			0.001
Yes	339 (58.8)	215 (48.3)	
No	238 (41.2)	230 (51.7)	

BMI: Body mass index. [a]Based on independent-samples *t* test or χ^2 test as appropriate; [b]The grouping of taking exercise refers to three times or more a week for "frequently", once or twice a week for "occasionally", and never or less than once a week for "seldom".

Relationship Between Fruit and Vegetable Consumption and Asthenopia As shown in Table 2, there was no

Table 2 Odd ratios of asthenopia by categories of fruit and vegetable intake OR (95%CI)

Dietary exposure	Levels of consumption (servings/wk)			$^{a}P_{trend}$
Total fruit and vegetable	≤6	7-8	≥9	
Asthenopia, *n* (%)	145 (58.0)	163 (50.9)	269 (59.5)	
Multivariate model 1[b]	1.00 (ref)	0.73 (0.52, 1.02)	1.06 (0.77, 1.46)	0.47
Multivariate model 2[c]	1.00 (ref)	0.67 (0.47, 0.95)	1.01 (0.72, 1.40)	0.63
Multivariate model 3[d]	1.00 (ref)	0.66 (0.46, 0.94)	0.97 (0.68, 1.37)	0.80
Total vegetable	≤3	4-5	≥6	
Asthenopia, *n* (%)	60 (58.3)	228 (53.6)	289 (58.5)	
Multivariate model 1	1.00 (ref)	0.81 (0.52, 1.26)	0.98 (0.63, 1.52)	0.51
Multivariate model 2	1.00 (ref)	0.83 (0.52, 1.32)	0.96 (0.61, 1.51)	0.72
Multivariate model 3	1.00 (ref)	0.82 (0.51, 1.31)	0.94 (0.58, 1.50)	0.78
Dark-green leafy vegetable	≤1	2-3	≥4	
Asthenopia, *n* (%)	66 (64.1)	183 (54.8)	328 (56.1)	
Multivariate model 1	1.00 (ref)	0.63 (0.39, 1.00)	0.68 (0.44, 1.06)	0.32
Multivariate model 2	1.00 (ref)	0.59 (0.36, 0.96)	0.66 (0.41, 1.05)	0.34
Multivariate model 3	1.00 (ref)	0.55 (0.33, 0.90)	0.60 (0.37, 0.97)	0.21
Fruit	≤1	2-3	≥4	
Asthenopia, *n* (%)	55 (51.4)	254 (58.3)	267 (55.9)	
Multivariate model 1	1.00 (ref)	1.29 (0.84, 1.99)	1.20 (0.78, 1.85)	0.73
Multivariate model 2	1.00 (ref)	1.19 (0.76, 1.87)	1.06 (0.68, 1.66)	0.83
Multivariate model 3	1.00 (ref)	1.19 (0.75, 1.87)	1.01 (0.64, 1.60)	0.61

OR: Odd ratio; CI: Confidence interval; ref: Reference group. ^{a}P for trend values were calculated across the categories of fruit and vegetable intake by dealing each categorical variable as a continuous variable in the model; [b]Covariates: age, gender, BMI, taking exercises, smoking, alcohol drinking, sleep time per day, mental state; [c]Covariates: included the variables listed in [b]Covariate plus refractive status, years of wearing glasses, daily computer use, viewing angle of computer screen, using any radiation reducing filter on the monitor, taking breaks during the use of computer, parents' use of glasses; [d]Covariates: further added dietary intakes of staple food, meat, sugar-sweetened beverages, fried foods and instant noodles into the model in addition to the variables listed in footnote c.

significant association between total fruit and vegetable intake and asthenopia risk in the demography- and lifestyle-adjusted model. After adjusting for visual function estimates, eye care habits and dietary variables, the relation was still null but showed a protective trend, with the OR being 0.84 (95%CI: 0.57-1.24, P_{trend}=0.39) in the top category versus the bottom. For the same comparison, we found that neither total vegetable intake nor fruit intake was associated with the risk of asthenopia.

We further analyzed the association between increasing consumption of dark-green leafy vegetable and the risk of asthenopia by using the same model adjustment. A higher intake of dark-green leafy vegetable was associated with a non-significant lower risk of asthenopia (OR: 0.68, 95%CI: 0.44-1.06, P_{trend}=0.32). Further adjustment for eye-related factors only slightly changed this result, and the inverse association remained non-significant, with the multivariate OR being 0.66 (95%CI: 0.41-1.05, P_{trend}=0.34) comparing extreme categories. After adjustment for the dietary variables, this association was further strengthened: individuals who consumed ≥4 servings/wk of dark-green leafy vegetable were likely to have a 40% decrease in the risk of getting asthenopia (OR: 0.60, 95%CI: 0.37-0.97, P_{trend}=0.21) compared with those who consumed ≤1 serving/wk of dark-green leafy vegetable.

In the stratified analyses by grade and sleep quality, the association between dark-green leafy vegetable intake and asthenopia did not appear to differ appreciably (Table 3). When we further conducted stratified analysis defined by eyesight status, the inverse association was limited to participants who had suboptimal eyesight (myopia or hyperopia), with the multivariate OR across extreme categories being 0.45 (95%CI: 0.25-0.82, P_{trend}=0.05). Similarly, stratification by wearing glasses showed a stronger OR for asthenopia within participants with spectacles (OR: 0.35, 95%CI: 0.17-0.72, P_{trend}=0.03) than those without spectacles. In addition, highest category of dark-green leafy vegetable intake was significantly associated with a lower risk of asthenopia among students who used computer for over 3 hours per day; whereas, the relation did not reach statistical significance among participants who used the computer less. A stratified analysis for fruit intake was also conducted separately, and the results were similar for specific subgroups.

Table 3 Odd ratios of asthenopia by categories of dark-green leafy vegetable intake stratified by various characteristics of participants

OR (95%CI)

Dietary exposure	Levels of dark-green leafy vegetable intake (servings/wk)			$^aP_{trend}$
	≤1	2-3	≥4	
Stratified by grade				
Junior or below				
Asthenopia, *n* (%)	33 (63.5)	90 (62.9)	152 (61.0)	
Multivariate model[b]	1.00 (ref)	0.79 (0.37, 1.71)	0.75 (0.36, 1.55)	0.48
Senior or above				
Asthenopia, *n* (%)	33 (64.7)	93 (48.7)	175 (52.2)	
Multivariate model	1.00 (ref)	0.42 (0.20, 0.86)	0.54 (0.27, 1.07)	0.51
Stratified by sleep quality				
Good				
Asthenopia, *n* (%)	55 (67.1)	158 (59.8)	266 (59.1)	
Multivariate model[b]	1.00 (ref)	0.57 (0.32, 1.02)	0.58 (0.33, 1.00)	0.14
Poor				
Asthenopia, *n* (%)	11 (52.4)	25 (35.7)	62 (45.9)	
Multivariate model	1.00 (ref)	0.42 (0.12, 1.44)	0.99 (0.29, 3.42)	0.30
Stratified by eyesight				
Optimal eyesight				
Asthenopia, *n* (%)	20 (55.6)	46 (52.9)	97 (56.7)	
Multivariate model[b]	1.00 (ref)	0.79 (0.32, 1.99)	0.76 (0.32, 1.84)	0.60
Suboptimal eyesight				
Asthenopia, *n* (%)	46 (68.7)	137 (55.5)	231 (55.8)	
Multivariate model	1.00 (ref)	0.46 (0.25, 0.84)	0.45 (0.25, 0.82)	0.05
Stratified by wearing glasses				
Yes				
Asthenopia, *n* (%)	39 (73.6)	110 (60.8)	190 (59.4)	
Multivariate model[b]	1.00 (ref)	0.36 (0.17, 0.77)	0.35 (0.17, 0.72)	0.03
No				
Asthenopia, *n* (%)	27 (54.0)	73 (47.7)	138 (52.1)	
Multivariate model	1.00 (ref)	0.73 (0.37, 1.45)	0.81 (0.41, 1.57)	0.78
Stratified by computer use duration				
≥3h/d				
Asthenopia, *n* (%)	43 (69.4)	97 (55.4)	180 (52.9)	
Multivariate model[b]	1.00 (ref)	0.49 (0.25, 0.97)	0.48 (0.25, 0.93)	0.08
<3h/d				
Asthenopia, *n* (%)	23 (56.1)	86 (54.1)	148 (60.4)	
Multivariate model	1.00 (ref)	0.75 (0.33, 1.72)	1.00 (0.46, 2.19)	0.50

OR: Odd ratio; CI: Confidence interval; ref: Reference group. [a]*P* for trend values were calculated across the categories of dark-green leafy vegetable intake by dealing each categorical variable as a continuous variable in the model; [b]Covariates in stratified analysis included age, gender, BMI, taking exercises, smoking, alcohol drinking, refractive status, years of wearing glasses, daily computer use, viewing angle of computer screen, using any radiation reducing filter on the monitor, taking breaks during the use of computer, sleep time per day, mental state, parents' use of glasses, dietary intakes of staple food, meat, sugar-sweetened beverages, fried foods and instant noodles, except for the stratifying-related variables *per se*.

DISCUSSION

In this study of Chinese college students, we found that a higher intake of dark-green leafy vegetable would decrease the risk of asthenopia in participants with suboptimal eyesight, a habit of wearing glasses or computer using for over 3h per day. This association was independent of other important risk factors for asthenopia, as well as other dietary confounders.

Recent studies have evaluated the epidemiological feature of asthenopia in college students, presenting a grim situation. A cross-sectional study by Leccese *et al*[14] showed that 90%

of the interviewees (135 out of 150 students) declared visual fatigue during long Computer-Aided Design (CAD) sessions. Additionally, Drew *et al*[15] reported that the mean eyestrain symptom score was 20.7±12.4 among 47 undergraduate students, higher than it was in a previous college sample[16]. In our study, the prevalence rate of asthenopia from doing near work among college students in Xi'an reached as high as 57.0%. Thus, it is urgent to develop effective strategies to protect against asthenopia and maintain the eye health of college students.

So far, some intervention studies have suggested the role of dietary supplementation to the objective and subjective parameters of asthenopia. An eight-week bilberry extract supplementation, in contrast to placebo group, alleviated the subjective symptoms of eye fatigue (including ocular pain, eye heaviness, uncomfortable sensation, and foreign body sensation) and reduction in critical flicker fusion which were induced by an acute video display terminal (VDT) load[17]. Another double-blind, randomized, and placebo-controlled trial showed that asthenopia symptoms (such as stiff shoulder, low back pain, frustration, dry-eye and stuffy head) and a score of mental fatigue were improved in subjects after a dietary intervention containing omega-3 fatty acid-rich fish oil, bilberry extract, and lutein[18]. However, evidence of habitual dietary factors in relation to the asthenopia risk remains sparse, especially among college students. To our knowledge, this is the first study to investigate the quantitative relationship between daily consumption of fruit and vegetable and the risk of asthenopia among college students. Several prior studies have reported an inverse association of fruit and vegetable intake with certain types of age-related eye diseases, including AMD and cataract[19-20], which provided appreciable evidence for the potential benefits of fruit and vegetable intake in eye health. In accordance with previous research[17-20], our results showed that highest category of dark-green leafy vegetable intake (≥4 servings/wk) was associated with a lower risk of asthenopia, compared with the lowest category (≤1 serving/wk).

The mechanisms by which dark-green leafy vegetable intake may alter asthenopia risk are speculative. Dark-green leafy vegetable contain several eye-protective nutrients, such as carotenoids (*i.e.* lutein, zeaxanthin) and vitamins[5]. Lutein and zeaxanthin selectively accumulate in the macula and are jointly referred to as macular pigment (MP)[21]. It has been indicated that augmentation of MP would enhance contrast sensitivity, improve glare disability and photostress recovery by attenuating the adverse impact of chromatic aberration and filtering blue light[22-23]. Several clinical trials have reported that supplementation with these carotenoids could enhance visual function and comfort, thus improving visual performance among people with degenerative eye diseases[24] or healthy eyes[22-23]. These findings have methodically suggested the putative association between consumption of dark-green leafy vegetable and the lowered risk of asthenopia observed in our study. In addition, dietary carotenoids, fiber as well as vitamins from dark-green leafy vegetable could act as protective antioxidants and potent scavengers of free radicals, which may reduce oxidative stress-induced damage to retina, eye muscles and visual nervous system caused by light radiation and tedious visual tasks, thereby preventing the occurrence of asthenopia[25-26]. Yagi *et al*[27] reported that a supplementation with lutein and zeaxanthin could aid recovery from visual fatigue with larger eye fixation related potentials amplitude from pre- to post-proof reading task. Furthermore, studies have also suggested that the lutein-rich dark-green leafy vegetable may be beneficial in improving visual function through enhancing gap junctional communication and increasing neuronal signaling efficiency in the eye[28-29].

It should be noted that the inverse association between dark-green leafy vegetable intake and asthenopia risk was limited to students who had suboptimal eyesight, wore glasses or used the computer for prolonged hours per day. Possible reasons may be that uncorrected refractive error[30], wearing spectacles[31] and prolonged computer use[32] have been identified as strong predictors for asthenopia; hence, the effect of dark-green leafy vegetable intake was more significant among these subgroups. This indicates that participants with poor eyesight and eye hygiene may benefit more from an increased intake of dark-green leafy vegetable to maintain eye health by preventing against visual fatigue.

The strengths of our study include its multi-stage stratified cluster sampling method, detailed structured questionnaire design, strict quality control, and high response rates. However, several limitations should be noted as well. The major concern of this study was its observational nature; therefore, our results were strictly statistical associations, which provided clues but not definite causal effects. Secondly, the ascertainment of asthenopia relied on participants' self-reported subjectively quantified symptoms, though reliable and valid, was not the same as clinical diagnoses made by a specialist with objectively measured parameters. Thirdly, refractive status of participants was assessed *via* self-administrated questionnaire, which could lead to the risk of misclassification, mitigating the differences in stratified analysis. Fourthly, selection bias could not be eliminated despite the high response rate and unified approach applied in this study. Furthermore, measurement error associated with dietary assessment was inevitable; however, this error would generally tend to bias the results toward the null, which may explain the non-significant association of total fruit and vegetable intake and asthenopia risk in our analysis. Lastly, the survey sample was drawn from college students in China, which restrains the generalizability of our findings to other population.

In summary, the results of this study indicated that higher dark-green leafy vegetable intake was associated with a reduced asthenopia risk among college students with suboptimal eyesight and poor eye care habits. Considering the high prevalence of asthenopia and its serious adverse health effects among college students, our findings may yield important public health implications if further confirmed by appropriately designed dietary intervention trials.

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