• Investigation •

Frequency and associated factors of accommodation and non-strabismic binocular vision dysfunction among medical university students

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Abstract

● **AIM:** To investigate the frequency and associated factors of accommodation and non-strabismic binocular vision dysfunction among medical university students.

● **METHODS:** Totally 158 student volunteers underwent routine vision examination in the optometry clinic of Guangxi Medical University. Their data were used to identify the different types of accommodation and non-strabismic binocular vision dysfunction and to determine their frequency. Correlation analysis and logistic regression were used to examine the factors associated with these abnormalities.

● **RESULTS:** The results showed that 36.71% of the subjects had accommodation and non-strabismic binocular vision issues, with 8.86% being attributed to accommodation dysfunction and 27.85% to binocular abnormalities. Convergence insufficiency (CI) was the most common abnormality, accounting for 13.29%. Those with these abnormalities experienced higher levels of eyestrain (χ^2=69.518, *P*<0.001). The linear correlations were observed between the difference of binocular spherical equivalent (SE) and the index of horizontal esotropia at a distance (*r*=0.231, *P*=0.004) and the asthenopia survey scale (ASS) score (*r*=0.346, *P*<0.001). Furthermore, the right eye's SE was inversely correlated with the convergence of positive and negative fusion images at close range (*r*=-0.321, *P*<0.001), the convergence of negative fusion images at close range (*r*=-0.294, *P*<0.001), the vergence facility (VF; *r*=-0.234, *P*=0.003), and the set of negative fusion images at far range (*r*=-0.237, *P*=0.003). Logistic regression analysis indicated that gender, age, and the difference in right and binocular SE did not influence the emergence of these abnormalities.

● **CONCLUSION:** Binocular vision abnormalities are more prevalent than accommodation dysfunction, with CI being the most frequent type. Greater binocular refractive disparity leads to more severe eyestrain symptoms.

● **KEYWORDS:** optometry clinic; non-strabismic binocular vision dysfunction; college students; convergence insufficiency

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INTRODUCTION

Electronic products and close-eye tasks have become increasingly common, leading to a high prevalence of accommodation and non-strabismic binocular vision dysfunction among college students[1-2]. Symptoms of binocular eyestrain, such as red vision, headaches, diplopia, difficulty concentrating, and fatigue, were reported inconsistently in different kinds of literature[2-6]. These symptoms among college students were found to be related to abnormal adjustment function and/or non-strabismic binocular visual function[7]. The long-term use of close-eye tasks promotes the adaptation of the accommodation and assembly system, which may explain the high prevalence of these abnormalities[8-9]. Despite the international scope of binocular vision survey projects, there is a scarcity of comprehensive research reports on the prevalence of these abnormalities among young people in China. This study aimed to investigate the frequency of these abnormalities among undergraduates of Guangxi Medical University in the optometry clinic and analyze the associated factors, so as to understand the common binocular vision dysfunction in college students and guide the practice of clinicians.

SUBJECTS AND METHODS

Ethical Approval This study was approved by the Ethics Committee of Guangxi Medical University (No.2022-key-069) with the written informed consent of all participants.

Subjects From June to December 2022, a total of 158 students aged 19 to 26y were recruited from the optometry clinic of the First Affiliated Hospital of Guangxi Medical University for a routine vision examination, with 65 males and 93 females (21.69±1.45 years old). To participate in the study, individuals must have a visual acuity of at least 1.0 in one eye. This study excluded students with 1) any ocular organic disease that affects corrected vision and binocular vision function examination; 2) a history of amblyopia and explicit strabismic; 3) a history of ophthalmic surgery including refractive surgery and strabismic surgery; 4) extraocular muscle injury due to any reason such as extraocular muscle surgery or trauma; 5) any eye or systemic medications that have been recently or are currently being used. Information to identify individual participants is available during data collection.

Methodology All students underwent an eye health assessment, which included a slit-lamp examination of the anterior segment, fundus examination, and binocular visual function examination. This was done in the following order: subjective and objective refractive status examination, Worth 4 dot test, distant and near horizontal eye position (Von Graefe method), accommodation convergence/accommodation (AC/A; calculation method), positive fusion divergence (PFV), and negative fusion divergence (NFV), positive relative accommodation (PRA), negative relative accommodation (NRA), monocular accommodation amplitude (MAA), accommodation response (fusion cross column mirror method), and near point of convergence (NPC). Additionally, an intelligent refractive function tester was used to adjust the monocular accommodative facility (MAF; ±2.00 D flip mirror, allowing the subject to focus on the myopia marker at a distance of 40 cm, which is the upper line of letters for optimal vision), and vergence facility (VF; 3ΔBI/12ΔBO). Myopia was defined as spherical degree ≤-0.50 D; hyperopia as spherical degree ≥+0.75 D; and astigmatism as astigmatism >0.50 D. Lastly, a questionnaire survey on eyestrain was conducted using the asthenopia survey scale (ASS) designed by Lin *et al*[10]. Scores of 16 or higher on the 19 symptom items indicated the presence of eyestrain. All binocular vision examinations were based on the subject's binocular refractive correction, and the classification criteria of accommodation and non-strabismic binocular vision dysfunction were based on research by Scheiman and Wick[11]. In contrast, the diagnostic criteria were based on research by García-Muñoz *et al*[2]. The diagnosis was made in combination with the students' symptoms.

Statistical Analysis Using the Power Analysis and Sample Size 15 software based on Majumder and Ling[12] research, the frequency of non-strabismic binocular vision anomalies (NSBVA) among students using visual display devices in a Malaysian university was 40%, with a 95% confidence interval of 0.2, resulting in a sample size of 154. SPSS 26.0 was used for statistical analysis, with right-eye data selected for all monocular measurements. Counting data was expressed in examples and percentages. Pearson Chi-square analysis was used to analyze the constituent ratio classification data. Pearson and Spearman's tests were used for correlation analysis depending on the distribution. Logistic regression analysis was used to analyze the associated factors of accommodation and non-strabismic binocular vision dysfunction. All tests were done bilaterally, with a *P*-value of less than 0.05 being statistically significant.

RESULTS

Overview of Results Of the 158 students in this group, 92.41% (146) had a refractive error (RE), with an average spherical equivalent (SE) of -4.43±2.49 D. Of these, 93.0% (n=147) were myopic, ranging from -0.50 to -9.50 D, 0.6% (n=1) were hyperopic, and 37.3% (n=59) had astigmatism. The 6.33% (n=10) had emmetropia. Of the students with RE, 36.08% (n=57) were either overcorrected, undercorrected, or had no glasses. Additionally, 72.78% (115/158) had close eye contact for more than 8h daily.

Ratio of Outpatients with Accommodation and Non-strabismic Binocular Vision Dysfunction Of the 158 students, 58 were diagnosed with symptomatic accommodation and non-strabismic binocular vision dysfunction, comprising 36.71% (23 male and 35 female). The average age of these students was 21.79±1.54y. The overall abnormal accommodation function was 8.86%, while the binocular vision was 27.85%. Convergence insufficiency (CI) was the highest contributor, at 13.29% (21/158). CI accounted for 10.76% (17/158), followed by basic exophoria (BX) at 6.96% (11/158). Accommodative infacility (AIF) was the most frequent abnormal accommodation, accounting for 6.33% (10/158) and accommodative excess (AE) was 2.53%, but no patients with accommodative insufficiency (AI) were found. Table 1 illustrates the comparison of the frequency of accommodation and non-strabismic binocular vision dysfunction between this study and other studies. Among those with RE, 20 (35.09%) had either been overcorrected, undercorrected, or had no glasses. In addition, it can be seen from Table 1 that CI accounted for

Table 1 Comparisons of frequency between other studies and the present study on accommodation and non-strabismic binocular anomalies

Study	García-Muñoz[2]	Shrestha[3]	Franco[4]	Darko-Takyi[5]	Liu[6]	Current study
Country	Spain	Nepal	Portuguese	Ghana	China	China
Population	University students	Medical students	Optometric clinics	Optometric students	Optometric clinics	Optometric clinics
Sample size (*n*)	175	284	156	105	172	158
Age (y)	22.90±3.96 (18-35)	22.98±1.80	25.8±5.3 (18-35)	19-27	21.20±4.90 (12-35)	21.79±1.54 (19-26)
AI (%)	2.29	1.76	11.54	4.70	0.6	0
AIF (%)	0	0.70	5.77	6.70	4.0	6.33
AE (%)	2.86	0.35	3.85	1.90	4.6	2.53
CI (%)	5.14	13.38	7.05	1.90	12.8	10.76
BX (%)	0	0	0	1.90	2.9	6.33
BE (%)	0	0	0	4.70	1.2	1.27
CE (%)	2.86	2.82	3.85	1.00	6.4	5.06
DE (%)	0.57	6.34	0	0	0.6	0.63
DI (%)	0	1.06	0	2.9	0	0
FVD (%)	0.57	0	0	0	2.9	0
CI+AIF (%)	-	-	-	-	0.6	1.27
CI+AE (%)	0.57	-	-	-	-	0.63
CI+AI (%)	1.14	-	-	-	0.6	0.63
CE+AE (%)	-	-	-	-	-	0.63
BX+AE (%)	-	-	-	-	0.6	0.63
RE (%)	45.14	-	66.7	59.0	96.5	92.41
Total (%)	13.14	27.82	32.05	34.30	36.1	36.71

AI: Accommodative insufficiency; AIF: Accommodative infacility; AE: Accommodative excess; CI: Convergence insufficiency; BX: Basic exophoria; BE: Basic esophoria; CE: Convergence excess; DE: Divergence excess; DI: Divergence insufficiency; FVD: Fusional vergence dysfunction; RE: Refractive error.

the highest proportion in most studies, and a high proportion of patients with accommodation and non-strabismic binocular vision dysfunction were detected in the optometry clinic.

Visual Fatigue in Outpatients Out of 158 students, 66 (41.77%) had a total symptom score of 16 or higher on the ASS. Of these, 58 (87.88%) had accommodation and non-strabismic binocular vision dysfunction, while 8 (87.88%) had normal or only slightly abnormal accommodation and binocular visual function tests. On the other hand, 92 (58.23%) had a total symptom score of less than 16 on the ASS, with 73 (79.35%) having a normal adjustment and binocular visual function tests. Nineteen cases (20.65%) had symptoms of accommodation or binocular visual dysfunction, including 6 cases with exophoria of large degrees in nearsightedness, 3 cases with esophoria of large degree in nearsightedness, 3 cases with exophoria of greater degree of farsightedness, 3 cases with spasm of accommodation, and 4 cases with AIF. Eyestrain was found higher among students with accommodation and non-strabismic binocular vision dysfunction (χ^2=69.518, P<0.001), as shown in Table 2. The top three symptoms of eyestrain[10] among students with these abnormalities were eye discomfort caused by screen brightness of electronic products such as mobile phones/computers (93.10%, 54/58), eye acid (87.93%, 51/58), and blurred vision in far or near sight (82.76%, 48/58).

Factors Associated with Accommodation and Non-Strabismic Binocular Vision Dysfunction In this study, we observed a linear relationship between the binocular SE difference and the index of distant horizontal esotropia, as well as the ASS score (P<0.05). The greater the binocular SE difference, the higher the index of distant horizontal esotropia and the ASS score. Additionally, the SE of the right eye was found to be linearly correlated with the convergence, divergence flexibility, and distant negative fusion ability set at close range. As myopia deepens, these abilities increase, as shown in Table 3. Furthermore, the ASS score was weakly correlated with the distance horizontal strabismic and monocular accommodation (P<0.05), as seen in Table 4. Lastly, multiple logistic regression was used to analyze the influencing factors of accommodation and non-strabismic binocular vision dysfunction, with gender, age, right eye SE, and bilateral SE difference as independent variables. The results showed that these variables were irrelevant factors for the frequency of accommodation and non-strabismic binocular vision abnormalities (Table 5).

DISCUSSION

The frequency of optometric outpatients and college students with accommodation and non-strabismic binocular vision dysfunction differed. Studies conducted in Portugal and China

Table 2 Number of subjects with symptomatic versus asymptomatic accommodation and non-strabismic binocular anomalies *n* (%)

Parameters	Accommodation and non-strabismic binocular abnormalities	Normal BV	Total
Symptomatic	58 (87.88)	8 (12.12)	66 (66.00)
Asymptomatic	19 (20.65)	73 (79.35)	92 (92.00)
χ^2		69.518	
P		0.000	

Normal BV: Normal binocular vision.

Table 3 Correlation between refractive status and binocular vision measures

Items	Binocular SE difference		SE of right eye	
	r	*P*	*r*	*P*
Stereopsis, arc sec	0.089	0.264	-0.067	0.402
Near horizontal heterophoria (△)	0.014	0.862	0.016	0.841
Distance horizontal heterophoria (△)	0.231	0.004	0.177	0.026
Near BO break point (△)	-0.051	0.528	-0.321	0
Near BI break point (△)	-0.087	0.274	-0.294	0
Distance BO break point (△)	-0.065	0.42	-0.113	0.157
Distance BI break point (△)	-0.1	0.213	-0.237	0.003
Near VF, cpm	0.021	0.79	-0.234	0.003
NPC, cm	0.002	0.976	0.131	0.102
MAF, cpm	-	-	0.122	0.127
MAA, D	-	-	0.027	0.732
ASS	0.346	0	-0.08	0.317

SE: Spherical equivalent; BO: Base out; BI: Base in; VF: Vergence facility; NPC: Near point of convergence; MAF: Monocular accommodative facility; MAA: Monocular accommodative amplitude; ASS: Asthenopia survey scale.

Table 4 Correlation between asthenopia questionnaire score and binocular vision measures

Items	*r*	*P*
Stereopsis, arc sec	0.121	0.129
Near horizontal heterophoria (△)	0.014	0.858
Distance horizontal heterophoria (△)	0.194	0.014
Near BO break point (△)	0.055	0.492
Near BI break point (△)	0.014	0.857
Distance BO break point (△)	0.007	0.933
Distance BI break point (△)	-0.032	0.686
Near VF, cpm	-0.052	0.520
NPC, cm	0.076	0.344
MAF, cpm	-0.070	0.381
MAA, D	-0.162	0.042

BO: Base out; BI: Base in; VF: Vergence facility; NPC: Near point of convergence; MAF: Monocular accommodative facility; MAA: Monocular accommodative amplitude.

showed the prevalence rate of the 18-35-year-old population to be 32.05%[4] and 36.1%[6], respectively. Meanwhile, the prevalence rate of college students from Spain, Malaysia, Ghana, and Nepal was 13.15%[2], 40%[12], 34.3%[5], and 27.82%[3], respectively. The findings of this study revealed a higher frequency rate of 36.71% among optometric outpatients

Table 5 Logistic regression analysis of associated factors of accommodation and non-strabismic binocular vision abnormalities

Factor	*n*	OR	95%CI	*P*
Gender				
Male	65	1	Reference	0.547
Female	93	1.340	0.517-3.472	
Age, y	158	1.055	0.773-1.440	0.737
SE (right eye)				
<-3.00 D	49	1	Reference	0.894
≥-3.00 D	109	0.920	0.270-3.131	
Binocular SE difference				
<1.5 D	126	1	Reference	0.394
≥1.5 D	32	1.641	0.525-5.128	

SE: Spherical equivalent; OR: Odd ratio; CI: Confidence interval.

of Guangxi Medical University, which is similar to the report of Liu *et al*[6]. This is likely due to the high intensity of close-eye use, the high proportion of RE among medical students, and the lack of standardized use of glasses. Research suggests that binocular vision abnormalities are more common among 18-35-year-olds[4], which may be attributed to the increased use of electronic devices for learning and work[13]. Medical students need to be more aware of their visual health needs due to their heavy workload, yet many do not wear glasses in a standardized manner and continue to strain their eyes for more than 8h a day. This may have an adverse effect on their performance in study and work.

Research conducted on Spanish college students[2], Nepalese medical students[3], urban and rural populations in Tamil Nadu, India[14], students in Addis Ababa, Nigeria[15], and optometry clinics in Northeast Sichuan[6] have all revealed that CI is the most common binocular vision dysfunction. However, Franco and Ling[4] discovered that AI (11.5%) was the most frequent functional abnormality among the Portuguese optometry clinic population, followed by CI (7.1%) and AIF (5.8%). Majumder and Ling[12] reported that dysregulation (15%) and convergence dysfunction (10%) were more prevalent among Malaysian college students who used visual display devices. Porcar *et al*[16] studied 89 electronic video terminal users and found that excessive aggregation was the most common. Lastly, Wajuihian[17] suggested that accommodation dysfunction is the most common among black South African populations aged 10 to 40. The high prevalence of myopia (93.0%) is likely the cause of the high incidence of CI, as it is one of the most common binocular vision disorders, affecting around 7.5% of the population[18]. Symptoms of CI are usually related to near-related activities, such as eye fatigue, headache, intermittent blurring or double vision, font movement on the page, difficulty concentrating, slow reading, and loss of position when reading. Variations in the proportions of different types of accommodation and non-strabismic binocular vision dysfunction could be attributed to ethnic differences in other regions, diverse sample populations, inconsistent diagnostic criteria for accommodation and non-strabismic binocular vision dysfunction, and clinical measurement techniques.

Of 158 students, 58 (36.71%) reported having eyestrain due to accommodation and non-strabismus binocular vision issues. These issues could not be solved solely by refractive correction but instead required adjustments to the prescription of spherical lens and prism and visual function training. Eight students had visible signs of visual fatigue, even though their adjustment and binocular visual function tests were normal. It was concluded that the cause of their symptoms may have been either simple ametropia that was not properly corrected or dry eyes causing visual fatigue. Of the eight, two had low myopia. They did not usually wear glasses, three had moderate myopia, with two of those not wearing glasses frequently and one wearing undercorrected glasses, two had anisometropia (2.00 D difference between two eyes) with dry eye syndrome, and one had high myopia with meibomian gland dysfunction. Nineteen students did not have obvious eyestrain symptoms at the examination time but had signs of abnormal adjustment or binocular visual function, mainly esotropia. Generally, the fusion reflex can compensate for esotropia, and patients will not have visible symptoms. However, eyestrain symptoms may appear when fatigue, tension, overuse of eyes in a poor environment, age, and other factors interfere with the decompensation of esotropia. Additionally, some patients may have a high pain threshold, leading them to close one eye while reading, resulting in difficulty with motor fusion[19]. Therefore, these students need to be monitored and observed in the optometry clinic.

This research found that the more significant the difference in binocular diopter, the greater the horizontal esotropia distance and the higher the ASS score. Furthermore, as myopia deepens, the convergence and divergence of near-distance fusion, the flexibility of convergence and divergence, and the convergence ability of far-distance negative fusion all increase, suggesting a relationship between the degree of myopia and convergence function. Regression analysis, however, showed that gender, age, and refractive status were not associated factors for the abnormal disease of accommodation and non-strabismic binocular vision. This is consistent with the findings of Liu *et al*[6] and Ma *et al*[20], who found that CI and dispersion deficiency were associated with RE. Hussaindeen *et al*[14] studied the prevalence of non-strabismic binocular vision dysfunction in school-aged children in Tamil Nadu, India. They found no significant difference in prevalence between urban and rural areas or gender orientation, but it did increase with age. Jorge *et al*[21] studied football players' race, position, age, and refractive status and found no significant difference in the distribution of binocular vision impairment between the above factors. Hashemi *et al*[22] discovered a substantial correlation between AI and gender among Iranian college students, with women being more commonly affected.

This study has some limitations. First, the sample size is limited, and the participants are self-selected, likely due to those with visual impairments or those who pay more attention to their eyesight being more likely to seek medical help. Additionally, the proportion of female participants is quite high at 58.86%, which could be attributed to women being more conscious of their visual health and the prevalence of gender bias.

In conclusion, this research reveals that CI is the most common binocular vision abnormality among students at Guangxi Medical University who attend optometry clinics, and both accommodation and non-strabismic abnormalities are prevalent. Therefore, clinicians should recognize this issue and intervene promptly to guarantee good visual function.

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