Refractive Errors and Binocular Vision Anomalies among Young University Students

Waleed M. Alghamdi[1], Muhammed S. Alluwimi[1], Sulaiman A. Aldakhil[1],
Majid A. Moafa[1] & Mansour A. Alghamdi[2]

[1] Department of Optometry, College of Applied Medical Sciences, Qassim University, Qassim, Saudi Arabia

[2] Department of Optometry, College of Applied Medical Sciences, King Saud University, Riyadh, Saudi Arabia

Correspondence: Waleed M. Alghamdi, Department of Optometry, College of Applied Medical Sciences, Qassim University, Qassim, Saudi Arabia. E-mail: walghamdi@qu.edu.sa

Abstract

It has been reported that refractive errors (RE) and binocular vision (BV) anomalies are common among university students. In this study we aimed to assess RE and BV status among university students in Saudi Arabia, and its relation to the academic performance. We recruited 109 participants (aged from 18 to 21 years). Visual acuity (VA) and objective refraction were used to assess the refractive status. Cover test, near-point convergence (NPC) and stereopsis tests were used to assess the BV status. Convergence insufficiency symptom survey (CISS) was applied to quantify near-work related symptoms. Mann-Whitney U test (p value was set as $p < 0.05$) was used to compare VA, CISS, NPC and the academic performance between the groups who had heterophoria versus orthophoria. We found that there was only 38% emmetrope, while the percentage of heterophoria was 45.8%. The academic performance was not statistically different among the two groups, but CISS and stereopsis scores were significantly different ($p < 0.03$). We concluded that RE and BV anomalies were common among university students in Saudi Arabia, but did not affect the academic performance. More studies are warranted to understand the low scores of CISS and stereoacuity, and their association with RE and BV anomalies.

Keywords: binocular vision, refractive error, university students

1. Introduction

There has been a worldwide growing concern regarding the prevalence increase for refractive error (RE) and binocular vision (BV) anomalies. According to the World Health Organization (WHO), the rise in the prevalence of RE and BV anomalies is a significant global public health concern (Bourne et al., 2017; French, Morgan, Burlutsky, Mitchell, & Rose, 2013; Wen et al., 2013). Binocular vision anomalies may include, but are not limited to, convergence insufficiency, heterophoria and unparalleled visual axes. These disorders can have an impact on many aspects of life, including academic performance, occupations and near work tasks. The specific mechanism of the presence of refractive error and the degree of binocular vision anomalies remains elusive.

Myopia is the most common RE and is found to be associated with higher levels of education and intensive near work (Wong, Foster, Johnson, & Seah, 2003). It was found that, in children, students with myopia had low academic success and poorer distance visual acuity (Hopkins, Narayanasamy, Vincent, Sampson, & Wood, 2020; Joseph, 2014). Hyperopia, on the other hand, is less common than myopia and has been found to significantly affect near-work tasks in children (Kulp et al., 2016). The amount of hyperopia and myopia could be changed as the eye grows. Consequently, there might be an effect on academic performance in adults. This led to the question of whether or not the presence of RE would influence educational achievement/near-work.

It has been reported that poor academic performance in school children is associated with BV anomalies (Falkenberg, Langaas, & Svarverud, 2019; Wood, Black, Hopkins, & White, 2018). On the other hand, it was found that BV anomalies are common in adult participants over 40(Leat et al., 2013; Pickwell, Viggars, & Jenkins, 1986). However, little is known about the BV status of adults over the age of 20 and under 40. College students are included in this age range, and it is crucial to assess their BV status because they certainly have a considerable number of near-work tasks for their study and work.

BV anomalies were found to be common among university students (García-Muñoz, Carbonell-Bonete,

Cantó-Cerdán, & Cacho-Martínez, 2016; Hokoda, 1985; Lara, Cacho, García, & Megías, 2001). Porcar (Porcar & Martinez-Palomera, 1997) demonstrated that many college students had BV anomalies, which negatively impacted their performance. Garcia-Munoz (García-Muñoz et al., 2016) suggested that university students should be clinically aware of BV anomalies. There is uncertainty regarding the effect of BV on the academic performance of university students since this effect could be considered as a milestone for achieving good academic performance, therefore, a stronger profile for job applications.

The assessment of RE and BV status among university students is unclear in Saudi Arabia. This study therefore aimed to assess the RE and BV status and their relationship with academic performance among university students.

2. Methods

2.1 Study Design

This study was a cross-sectional study conducted among first-year students (preparatory year) at Qassim University, Qassim, Saudi Arabia. The study included 109 participants who were randomly enrolled; their age ranged from 18-21 years old (mean ± standard deviation [SD]: 19.2 ± 0.8). Students were grouped based on their non- strabismic binocular vision (normal group or heterophoria group). This study was approved by local Ethics Committee at ministry of health - Qassim - Qassim office and was conducted according to the Declaration of Helsinki guidelines. Participants attended one visit, and all gave written informed consent after having the procedures of the study explained.

2.2 Study Procedures:

Medical/ocular history was taken for each participant, followed by visual acuity (VA) measurement, which was taken under monocular and binocular conditions. However, only the VA of the right eyes was included in the analysis. Also, data on Grade Point Average (GPA) was collected according to the students' self-report to indicate academic performance for the students.

The CISS Questionnaire

All participants were required to complete the convergence insufficiency symptom survey (CISS) questionnaire (Rouse et al., 2004). The CISS questionnaire is a valid and reliable questionnaire that consists of 15 items meant to quantify near work-related symptoms. A score of 21 or more is considered symptomatic when used with adults (Rouse et al., 2004).

2.3 Clinical Procedures

At first, objective refraction was performed with auto-keratorefractometer Topcon KR8900 (Topcon Co., Tokyo, Japan). The spherical equivalent of $\leq - 0.5$ diopter was considered myopia in this study, while hyperopia was defined as $+ 0.5$ diopters or greater. Heterophoria was assessed by unilateral and alternating prism cover tests performed at a distance (6 m) and near (40 cm) with the best possible correction. The magnitude of the deviation was measured using the alternating cover test and prism bar. *Exophoria* was defined as near exophoria more than 6 prism diopter (PD) and/or distance exophoria more than 3 PD, while *Esophoria* was defined as any near esophoria and/or distance esophoria more than 1 PD (Abdi, Lennerstrand, Pansell, & Rydberg, 2008).

Near point of convergence (NPC) was subsequently evaluated with the push-up technique by using Royal Air Force (RAF) ruler, and described as the distance at which the patient first noticed diplopia, or as the distance where convergence was visibly broken (whichever comes first). *Convergence insufficiency* was defined as NPC of 10 cm or greater in this study, accompanied by greater exophoria at near than at distance (Abdi et al., 2008; Leat et al., 2013). Finally, near stereo-acuity was measured using Titmus-fly stereopsis test (Stereo Optical Co., Inc., Chicago, IL, USA) (Garnham & Sloper, 2006), while color vision was screened with Ishihara plates (Birch, 1997).

2.4 Statistical Analysis

Statistical analyses were performed with the SPSS software package (V. 22.0, SPSS Inc., Chicago, IL, USA). Descriptive statistics are presented as (mean ± standard deviation) and frequencies as percentages. As all variables were non-normally distributed, the Mann-Whitney U test was used for the statistical comparison between groups. For categorical variables, cross-tabulation was used to describe the distribution of variable values, while Pearson Chi-Square was used for statistical comparison. Spearman's rho was used to evaluate associations between variables; $P < 0.05$ was considered statistically significant in this study.

3. Results

There were no statistically significant differences between the groups in age (Independent t-test p= 0.39). In this study, 50 out of 109 participants had heterophoria (45.8%), of which 14 participants (12.8%) had convergence

insufficiency (Table 1). Emmetropia was only reported in 39.4% of participants, where myopia was the most common refractive error (44.9%), followed by hyperopia (8.2%), and simple astigmatism was reported only in 7.3%. Color vision tested by Ishihara plats showed only 2 cases affected (out of 109).

Table 1. Prevalence of heterophoria and convergence insufficiency in the study sample (n=109)

Category	Sample (%)
Normal Binocular Vision	59 (54.2%)
Heterophoria	50 (45.8%)
esophoria at near	18 (16.5%)
exophoria at near	32 (29.4%)
Convergence insufficiency	14 (12.8%)

In this study, 54% of students with heterophoria were symptomatic (CISS score mean $\pm$ SD 20.5 ± 9.8) compared to 23% of the normal group (CISS score mean $\pm$ SD 20.5 ± 9.8), which was significantly different ($p= 0.027$) (Figure 1 and Table 2). Near stereo-acuity, measured by the Titmus-fly test, was significantly better in the normal group (mean $\pm$ SD 75 ± 82) than heterophoria group (136 ± 126, $p= 0.01$, Figure 2). Other variables, including VA, refractive error, NPC, and GPA, were not significantly different between groups (Table 2).
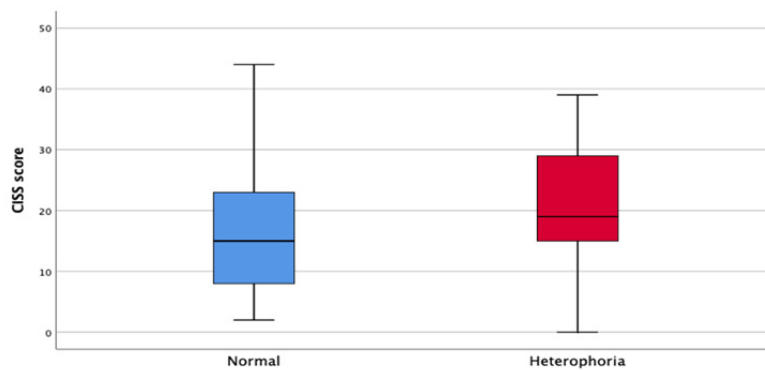

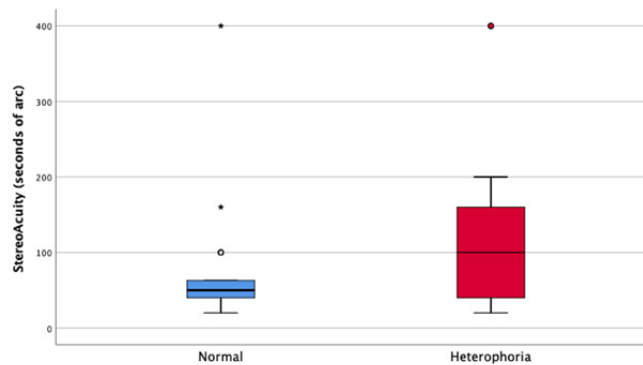Figure 1. Box plot of CISS score for normal and heterophoria groups

Figure 2. Box plot of stereo-acuity score for normal and heterophoria groups

Table 2. Group means and standard deviations of normal and heterophoria groups for different variables together with the outcomes of Mann-Whitney U analysis

Variable	Normal mean± SD	Heterophoria mean± SD	Mann-Whitney U P value
VA (Right Eye LogMar)	0.1 ± 0.1	0.1 ± 0.1	0.8
CISS score	16.6 ± 10.1	20.5 ± 9.9	**0.027**
NPC (Break) cm	6.97 ± 2.1	8.8 ± 5.2	0.3
NPC (Recovery) cm	9.7 ± 2.4	11.7 ± 5.4	0.2
Stereo-acuity	75 ± 82	136 ± 126	**0.01**
GPA (out of 5)	3.8 ± 0.9	3.9 ± 0.6	0.5

3.1 Correlation Analysis

The associations between different clinical variables are listed in table 3. Heterophoria showed moderate positive correlation CISS score (Spearman's r = 0.31, P-value =0.001) and slight positive correlation with stereo-acuity and NPC (recovery). Refractive error was significantly correlated with VA and stereo-acuity (Table 3). GPA did not correlate with any other parameters.

Table 3. Spearman rho (R) Correlation coefficients (r) analysis of different parameters and their p values

Variable	Correlation analysis	heterophoria	CISS score	Refractive error	VA (right eye)
heterophoria	r	1	**0.31**	0.07	0.04
	p value	.	**<0.01**	0.45	0.67
CISS score	r	**0.31**	1	-0.004	0.15
	p value	**<0.01**	.	0.96	0.11
Refractive error	r	0.07	-0.004	1	**0.53**
	p value	0.45	0.96	.	**<0.01**
Right VA	r	0.04	0.15	**.529**	1
	p value	0.67	0.11	**<0.01**	.
GPA	r	-0.12	0.06	-0.2	-0.15
	p value	0.37	0.61	0.12	0.25
NPC (Break)	r	0.21	0.02	0.01	0.07
	p value	0.04	0.83	0.94	0.45
NPC (Recover)	r	**0.19**	0.05	-0.02	0.05
	p value	**0.047**	0.59	0.82	0.61
Stereo-acuity	r	**0.24**	-0.01	0.18	-0.03
	p value	**0.011**	0.87	0.058	0.74

4. Discussion

The study undertook whether the RE and BV hamper students' abilities to succeed in academic performance at the university level. The results of this study showed that about 54% of the participants had normal binocular vision. Students with abnormal binocular vision had significantly lower scores of stereoacuity and the CISS compared with those who had normal binocular vision. However, a minor impact was found of BV anomalies on the academic performance.

Helveston (Helveston et al., 1985) studied the relationship between visual function and the academic outcome in

school children. There was no concrete relationship found between the academic performance of these children and their visual functions like VA, color vision, eye muscle balance, and refraction. Vaughn (Vaughn, Maples, & Hoenes, 2006) also conducted a study that focused on the vision quality of the individuals and their academic performance. They concluded that there was a relationship between visual impairments and the academic performances of the children.

The results of this study are consistent with the previous studies in terms of the minor impact of RE and BV anomalies on academic performance. Procar and Martinez-Palomera (Porcar & Martinez-Palomera, 1997) found that academic performance would be negatively affected by the non-strabismic anomalies. We found this negative effect in the stereoacuity and CISS, which showed lower scores for those who had abnormal BV than participants with normal BV. However, RE and general BV status did not affect the academic performance as measured by the GPA. Although Pickwell (Pickwell et al., 1986) reported that convergence insufficiency increases with age and may affect adults' visual functions, we did not find a significant difference in NPC between normal BV and abnormal BV groups.

One of the interesting results we found was that heterophoria was present in 46 % among participants; these participants were symptomatic according to the CISS questionnaire. In addition, participants affected with heterophoria had worse stereopsis and CISS score than normal ones. However, there was no significant relationship between the participants' visual functions and their GPA, which reflects their academic performances (p-value > 0.05).

Although there was no direct relationship between the general status of RE and BV, there were interesting observations regarding the BV and RE values in this study. The RE surprisingly had a high percentage (60.4%) of the total participants enrolled. As reported, uncorrected RE is one of the causes of visual impairment in Saudi Arabia. Therefore, extra caution should be taken to assess the refractive status of the students; and prescribe the appropriate refractive corrections.

In conclusion, we demonstrated how the visual functions of the participants did not affect the students' academic performance. However, heterophoria participants approximately represented half of the study sample; and were symptomatic. Stereoacuity and the CISS score warrant more research to understand the underlying causes of significant low scores in this study, and to evaluate their association with RE and BV anomalies. Careful clinical assessment of BV and RE status is essential, especially among university students, to maintain good academic performance and quality of life.

Funding Source

Competing Interests Statement

The authors declare that there are no competing or potential conflicts of interest.

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