MYOPIA AND BINOCULAR VISION FUNCTIONS AMONG ALLIED HEALTH SCIENCES STUDENTS AT IIUM

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ABSTRACT

Myopia is believed to have some effects on lag of accommodation, heterophoria and AC/A ratio. Previous studies reported that the lag of accommodation of myopic is higher compared to an emmetropic eye. It is also reported that the incident of exophoria in myopic eyes is more common compared to emmetropic eyes. Additionally, myopic individuals are anticipated to exhibit higher accommodative convergence compared to emmetropic individuals. This study aimed to investigate these effects on undergraduate students of Kulliyyah of Allied Health Sciences, particularly assessing how different the degrees of myopia impact these visual functions. The lag of accommodation, heterophoria and AC/A ratio of 82 participants were measured with full correction. The lag of accommodation was measured utilizing an autorefractor, Grand-Seiko WR-5100K while the heterophoria measurement was obtained by using the Howell Card and the AC/A ratio was measured by using the gradient method. The results revealed a significant difference in lag of accommodation between myopic and emmetropic students, but no significant differences in heterophoria and AC/A ratio between the two groups. When comparing various degrees of myopia, only the lag of accommodation showed a significant difference, while AC/A ratio and heterophoria remained unaffected. In summary, myopia primarily affects the lag of accommodation, with no significant impact on AC/A ratio and heterophoria in KAHS students' population. Thus, it is predicted that the possibility of myopia progression on these subjects are very low.

KEYWORDS: Myopia, lag of accommodation, heterophoria, AC/A ratio

INTRODUCTION

Myopia has emerged as a pressing public health issue in recent years, with its prevalence steadily rising annually (Wang et al., 2021; Singh et al., 2022; Zhang et al., 2022). This increasing trend reflects a global health concern driven, in part, by lifestyle shifts characterized by reduced outdoor activities and greater engagement in near work, as reported in various research findings (Brien et al., 2016). This surge in myopia not only increases the demand for corrective glasses but also raises concerns about eye-related problems and myopia progress. Moreover, myopia's impact extends beyond eye health, potentially influencing an individual's overall quality of life and psychological well-being (Nathan et al., 2019).

From an optometric perspective, myopia would affect various the binocular functions, such as lag of accommodation (LA), AC/A ratio and heterophoria. The LA represents the gap between the intended focus and the actual focusing response, with myopic individuals often showing higher LA than emmetropic individuals (Chen et al., 2020). Heterophoria, denoting the misalignment of the eyes when fusion is absent, can also be affected by myopia. Myopic individuals may exhibit an increased tendency toward exophoria at both near and distant vision (Jin et al., 2007). Myopia is likely to influence the AC/A ratio, which measures the connection between accommodation and convergence. This can lead to increased accommodative convergence in individuals with myopia (Gwiazda et al., 2005). Greater LA can lead to high AC/A ratio which an early sign of becoming myopic, however the rate of progression of myopia does not depending on these changes (Mutti, D.O, Mitchell, G.L., Jones-Jordan, L.A et al., 2017). Many researchers studied the effects of myopia on these visual functions in other countries with different populations (Jane, et al., 2004; Logan, et al., 2021).

This study focuses on understanding how myopia influences LA, heterophoria, and the AC/A ratio in undergraduate students at the Kulliyyah of Allied Health Sciences, IIUM. It also aims to see if different levels of myopia have varying effects on these functions.

MATERIALS AND METHODS

The study was cross-sectional, involving first year students of the Kulliyyah of Allied Health Sciences (KAHS), session 2022/2023. It utilized convenience sampling, and a total of 82 year 1 students participated (42% from the target population). The participants comprised of 20% and 80% male and female students respectively, with an average age of 20±1 years old. Data collection took place at the IIUM Optometry Clinic between October 28, 2022, and March 18, 2023.

Inclusion criteria for the study were as follows: participants needed to possess normal visual functions, normal binocular vision, have no history of ocular and systemic diseases, and had not undergone ocular surgery. The participants also had to have the best-corrected distance visual acuity of 6/6 or better and were either emmetropic or myopic, with spherical equivalent refraction (SER) ranging from -0.50DS to <-9.00DS.

The participants received an explanation about the study, and consent was obtained. Data collection included assessing participants' visual acuity using the Snellen Chart at 6 meters and determining refractive power using the Oculus PARK 1 auto-refractor and subjective refraction. Subsequently, participants were categorized into emmetropia and myopia, with the myopia group further divided into mild (≤-0.50D to – 2.75D), moderate (≤-3.00D to -4.75D), and high myopia (≤-5.00D) based on their refractive error (Tang et al., 2019; Flitcroft et al., 2019).

Following this, data regarding LA, heterophoria, and AC/A ratio were collected from the participants while they were wearing their full correction. To measure the LA, the Grand-Seiko WR-5100K was used with a crossed target. The LA was determined by calculating the difference between the average of three readings of distance and near refractive errors (Ortiz-Peregrina et al., 2021). Heterophoria measurements were carried out using the Howell Card and a phoropter, both at a distance and near. Participants were asked to report the number indicated by the arrow on the lower chart of the Howell Card with a 6-prism diopter base down was placed in front of the right eye (Anstice

et al., 2020). The AC/A ratio, which signifies the relationship between accommodation and convergence, was measured using the gradient method and a phoropter. This technique is commonly used in the clinical setting. Near phoria was measured both with and without an additional lens. If the subject exhibited esophoria, a +1.00 DS lens was employed as the additional lens, while if the participant displayed exophoria, a -1.00 DS lens was used. The AC/A ratio was then calculated using the formula described by Singh et al. (2017).

RESULTS

All the data obtained were analyzed using Statistical Package for Social Science Software (SPSS) (version 23 for Windows, SPSS, Inc., Chicago, IL, USA). The Shapiro-Wilk test is used to test the normality of all the data before running the test. As the data of LA and AC/A ratio in comparing between emmetropic and myopic students were normally distributed, independent *t*-test were used to analyze the data. However, the data for heterophoria at both distance and near were analyzed using the Mann-Whitney U test as those data were not normally distributed. When comparing the parameters between different degrees of myopia, only the data on the LA was normally distributed. Thus, a one-way ANOVA test was used. For analyzing the data of heterophoria and AC/A ratio, the Kruskal-Wallis H test was used.

Effect of myopia on LA

The independent *t*-test of the LA between the emmetropic and myopic students showed a $p<0.05$ (Table 1) which indicated that there was a significant difference between the LA of the emmetropic and myopic students (t (162) =2.74, p=0.007). The mean difference of the LA of the emmetropic students was higher than that of myopic students with a different of 0.18 (95% CI, 0.31 to 0.51).

Table 1 Comparison of lag of accommodation between emmetropic and myopic students

Variable	Emmetropic		Myopic		Mean differences (95% CI)	t-statistics (df)	*p*-value
	Mean	SD	Mean	SD			
Lag of accommodation (D)	+1.85	0.38	+1.67	0.41	0.18 (0.51, 0.31)	2.74 (162)	0.007

One-way ANOVA test of the LA between different degrees of myopia showed $p<0.05$ (Table 2). This indicated that there was a significant difference in the LA between the groups [F (3,160) =3.99, p=0.009]. A post hoc Dunnet test revealed that the LA of the high myopia was statistically significantly lower than that of the LA of the emmetropia (control group) (p=0.004, 95% CI= (-0.55, -0.08). There was no statistically significant difference in the LA between the other groups.

Table 2 Comparison of lag of accommodation between different degrees of myopic students (Control group = emmetropia)

Variable	n	Lag of accommodation (D)		F-statistic (df)	*p*-value
		Mean	SD		
Emmetropia	27	+1.85	0.37	3.99	0.009
Mild myopia	28	+1.67	0.40	(3)	
Moderate myopia	16	+1.75	0.34		
High myopia	11	+1.53	0.47		

Effect of myopia on heterophoria

Heterophoria for both distance and near between emmetropic and myopic students using the Mann-Whitney U test showed $p>0.05$ (Table 3) which indicated that there was no significant difference between both heterophoria at distance and near for the emmetropic and myopic students. The value was expressed in mean rank (Chen et al.,2003; Jung et al., 2016; Hong et al.,2020). However, the result is shown that both distance and near heterophoria of the emmetropic students was less exophoric than that of myopic students.

Table 3 Comparison of heterophoria between emmetropic and myopic students

Variable	Emmetropic	Myopic	z-value	*p*-value
	Mean rank	Mean rank		
Heterophoria at D (ΔD)	79.38	70.62	-1.24	0.214
Heterophoria at N (ΔD)	76.25	72.15	-0.55	0.577

In comparing the heterophoria at distance between the different degrees of myopia, the Kruskal-Wallis H test showed $p>0.05$, and at near showed $p>0.05$. These two results indicated that there were no significant differences in both distance and near heterophoria between the groups. Figures 1 and 2 illustrate the comparison of heterophoria at both distance and near between the different degrees of myopia, respectively.

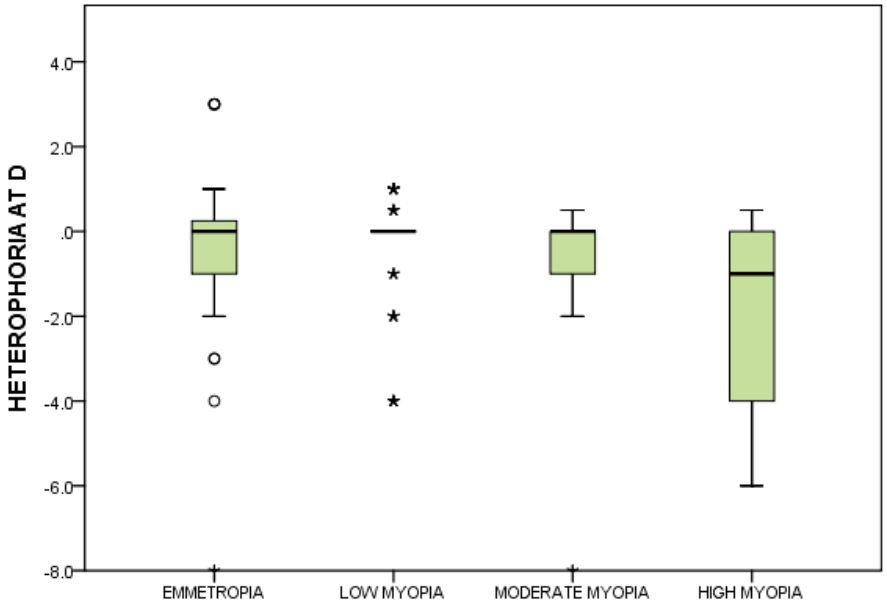

Figure 1 Boxplot of heterophoria at distance between different degrees of myopic students (Control group = emmetropia)

Note: minus sign on the y-axis indicates exophoria, while plus sign indicates esophoria.

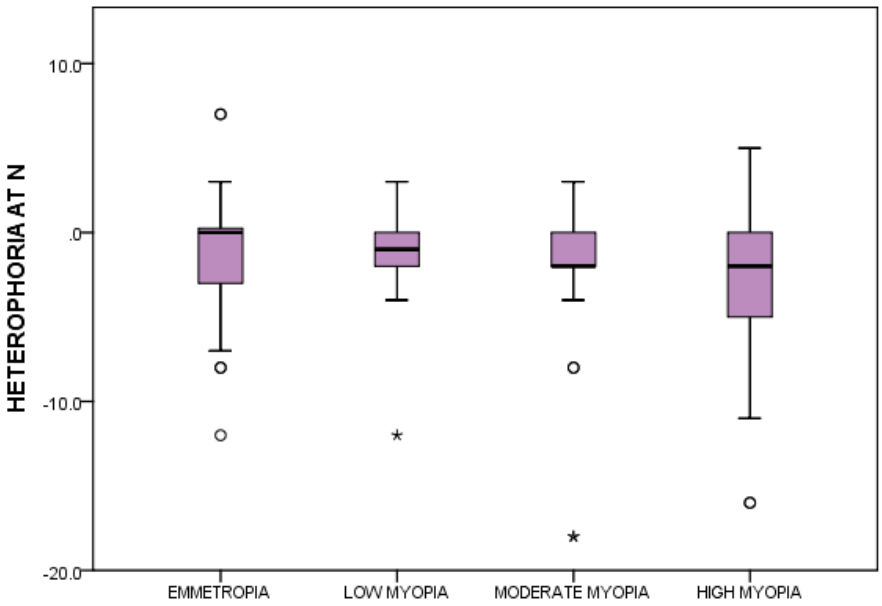

Figure 2 Boxplot of heterophoria at near between different degrees of myopic students (Control group = emmetropia)

Note: minus sign on the y-axis indicates exophoria, while plus sign indicates esophoria.

Though there is statistically insignificant result, myopic participants showed greater amount of exophoria for both distances as compared to emmetropic and lower degree of myopia.

Effect of myopia on AC/A ratio

The independent t-test of the AC/A ratio between the emmetropic and myopic students showed $p>0.05$ [t (144) =1.69, p=0.09] (Table 4). This indicated that there was no significant difference between the AC/A ratio of the emmetropes and myopes. The mean difference of the AC/A ratio between the groups showed that the emmetropes AC/A ratio was higher than that of the myopes.

Table 4 Comparison of AC/A ratio between emmetropic and myopic students

Variable	Emmetropic		Myopic		Mean differences (95% CI)	t-statistics (df)	*p*-value
	Mean	SD	Mean	SD			
AC/A ratio (D)	2.43	1.41	2.00	1.48	0.43 (-0.07, 0.94)	1.69 (144)	0.092

The Kruskal-Wallis H test of the AC/A ratio between different degrees of myopia showed a $p>0.05$. This indicated that there was no significant difference in the AC/A ratio between the groups. Figure 3 illustrate the comparison of the AC/A ratio between the different degree of myopia.

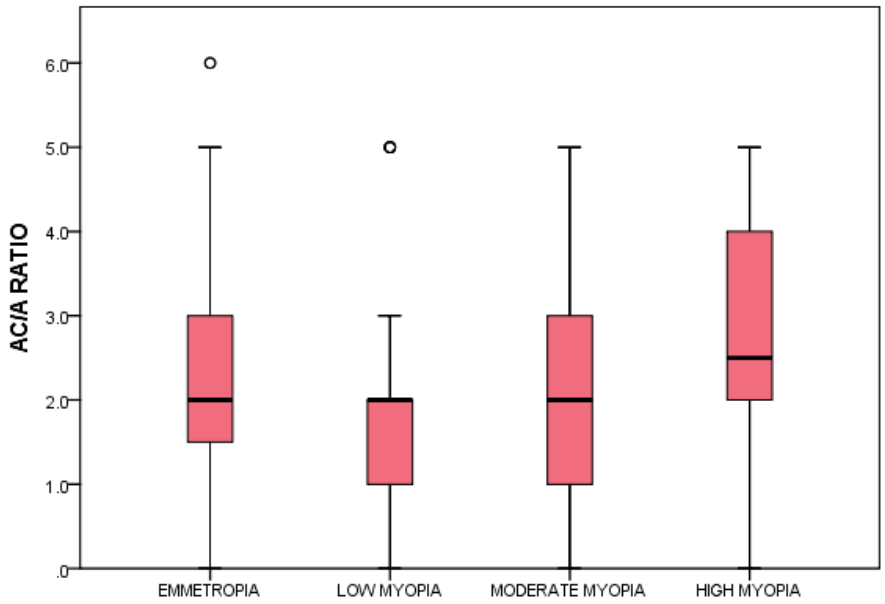

Figure 3 Boxplot of AC/A ratio between different degrees of myopic students (Control group = emmetropia)

DISCUSSION

Effect of myopia on lag of accommodation

In the investigation of the effect of myopia on the LA on KAHS year one students, it was shown that the LA of an emmetropes was higher than myopes. This study's results aligned with the findings of Tarrant et al. (2010), which had a total of 30 participants (age 23.5±2.9 years) in comparing the LA between the emmetropes and myopes utilizing Zernike and Seidel defocus wave aberrations, in which it also suggested that the accommodative LA for emmetropes was higher than that of the myopes. This similarity suggests some consistency in the results, despite differences in sample size and measurement techniques between the studies.

In contrast, findings from Nakatsuka et al. (2005) and Kaphle et al. (2022), in which these two studies found that myopes showed a larger LA than the emmetropes. The study by Nakatsuka et al. (2005) had a total of 79 Japanese children (age 9±3 years) who participated, and the LA was measured using the Grand Seiko WV-500 auto-refractometer. The result differ from current study could be due to near viewing distance of children was closer as they may accommodate inaccurately (Gwiazda, et al. 1993) as compared to adults which may lead to higher LA (Haro, C., Poulain, I. & Drobe, B. 2000). Kaphle and colleagues (2022) had a total of 76 young adults' participants (age 22.5±4.5 years) and the LA was measured using the Hartmann–Shack Complete Ophthalmic Analysis System aberrometer, utilizing pupil plane (Zernike refraction) and retinal image plane metrics. The different age groups in the study by Nakatsuka et al. (2005) and methods used in the study by Kaphle et al. (2022) may contributed to the contradicting results.

Higher LA in myopic was always related to the myopia progress which due to hyperopic defocus induced by LA, however previous finding showed that myopia progression was not related to higher LA (Chen, Y., Drobe, B., Zhang, C. et al; 2020). Though this is still unclear, at least for the group of current study, the prediction can be made that there is a low possibility of myopia progression to occur.

In addition, there was an analysis of whether the effect of myopia on the LA differs with different degrees of myopia

in the current study, but the results showed that only high myopia would give significant lower LA as compared to emmetropes.

Effect of myopia on heterophoria

The analysis of the effect of myopia on heterophoria in this study had shown that there was no significant difference in both distance and near heterophoria between the emmetropic and myopic participants. Moreover, the effect of different degrees of myopia on heterophoria also cannot be proven. The result of this study comparing the heterophoria between emmetropes and myopes was consistent with the study by Chen & Aziz (2003). The study recruited 36 students (age 21.5±2.5 years), and the heterophoria was measured using the Howell Card. The results showed that there was no significant difference in the heterophoria measured at distance and near between the emmetropes and myopes.

In contrast, the study by Hasebe et al. (2005) reported that myopes tend to be more exophoric at distance and more esophoric at near viewing distance. The study was conducted with a total of 95 Japanese children (age 9±3 years) and the measurement of heterophoria was done using a prism cover test. Myopic eye tends to exhibit esophoria at near as the have high AC/A ratio.

Similarly, a study by Leone et al. (2010) revealed that there was an association between myopia and exophoria at both distance and near among 12 years old children. The study had recruited 1740 students of age 6 years and 2353 students of age 12 years, and the heterophoria was measured using the prism cover test. The study reported a significant association between the refractive error and both heterophoria at distance and near in the age group of 12 years old, but not in the age group of 6 years old because the proportion of myopia in that age group was not sufficient to prove the association. The findings from those two studies were assumed to be different from current study due to the varying age groups and methods used to measure the heterophoria.

Effect of myopia on AC/A ratio

Regarding myopia and the AC/A ratio, it was found that there was no significant difference between the AC/A ratio of the emmetropic and myopic participants. A similar finding was reported in a study by Chen et al. (2003). The study was participated by 30 children in Hong Kong (age 10±2 years) and the AC/A ratio obtained was distance-induced and lens-induced AC/A ratio, calculated by the formula. The study had showed similar result with this study as it was reported that there was no statistically significant difference in the AC/A ratio between the myopes and emmetropes even though the study design and method were different from this study.

Furthermore, the investigation of the effect of different degrees of myopia on the AC/A ratio in this study also resulted in a non-significant difference in the AC/A ratio between the myopia groups. However, there was an apparent trend with myopia and AC/A ratio in which, the AC/A ratio tends to increase with the extent of myopia. This result was consistent with a study by Tsai et al. (2012).

In contrast, the study by Mutti et al. (2000) reported that the AC/A ratio was associated with the refractive error in which the myopes had a higher AC/A ratio than that of emmetropes. But they found that there is no significant difference in the AC/A ratio with different degrees of myopia. That study was conducted with 847 children (age 10.5±4.5 years), and the AC/A ratio was calculated using a specific formula. It was assumed that due to the difference in the population studied and the method used in those study, the results shown were also different.

CONCLUSION

The outcomes revealed that myopic individuals exhibit a significantly lower LA in comparison to those who are emmetropic. There were non-significant results on heterophoria and AC/A ratio, however, myopic individuals consistently exhibit greater exophoria values and lesser AC/A ratio as compared to emmetropic. The findings in this

study may be different from the others due to the difference in the population studied and the methods used in the research. However, based on previous studies mentioned above, it can be predicted that the participants in this group may have a reduced likelihood of myopia progression, though these association were still unclear. In the future, longitudinal study involving the same participants (in year 2 and year 4) could be conducted to ascertain whether this prediction is true.

ETHICAL APPROVAL

There is no conflict of interest in this study, and we did not receive any specific grant or funding. The study adhered to the tenets of the Helsinki Declaration involving human subjects and received ethical approval from the IIUM Research Ethics Committee (IREC), with ethical approval number IREC 2022 KAHS/DOVS/13.

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