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RESEARCH ARTICLE

A Two-Year Longitudinal Study of Refractive Error and Ocular Biometry among Young Adults in Brazil

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ABSTRACT

Background: The prevalence of myopia is increasing worldwide. Several studies were reported about myopia progression in the adult population with a high level of education.

Objective: To investigate the changes in refractive errors, biometric measurements, and environmental variables among medical university students during two years in Brazil.

Methods: A two-year longitudinal prospective study was proposed. Cycloplegic refractive examinations were conducted, and corneal topography and ocular optical biometry. The lens power was calculated by Bennett and Rozema's formula. A questionnaire on lifestyle visual activities was applied. Only participants with normal ophthalmological exams were included in the study. Statistical significance was assessed at the level of 0.05.

Results: One hundred twenty-eight students were eligible for the first exams and 89 (69.53%) completed the two-year follow-up. The mean age at baseline was 21.00 ± 1.92 years. Thirty-seven (41.57%) participants were males. Regarding refractive errors, 11 (12.36%) were hyperopic, 28 (31.46%) were emmetropic, 45 (50.56%) were myopic, and 5 (5.61%) were high myopic. There was a positive correlation between refraction and axial length in all groups, and a negative correlation with lens power. No significant two-year change in K_m was found in all groups. The average of hours per day spent in outdoor and near-work activities were 1.36 ± 0.8 and 8.66 ± 1.77 h, respectively.

Conclusion: The results showed that the main correlation to change in refraction was axial length. There were some cases of myopia progression in myopic students. The contribution of crystalline lens power for keeping slow myopia progression was significant.

Keywords: Refractive Errors; Myopia; Axial Length; Ocular Biometry; Cycloplegic Refraction.

1. List of Abbreviations

AL = Axial length.
CAAE = Certificado de apresentação para apreciação ética.
MT = Mato Grosso, state from Brazil.
Km = Mean keratometry.
SD = Standard deviation.
SER = Spherical equivalent refraction.
UNIVAG-MT = Centro Universitário de Várzea Grande, Mato Grosso, Brazil.

2. Introduction

Emmetropia, as a term, refers to the ocular refractive state of the eye, wherein the image is focused on the retina during periods of relaxation of accommodation.[1] For the classification of emmetropia, the refractive error ranges between > -0.50 D and +0.50 D in most studies in adults, while hyperopia ≥ 0.75 D, with higher limits for schoolchildren as low hyperopia is the rule at early ages. In general, myopia is the refractive ocular condition when spherical equivalent refraction (SER) is ≤ -0.50 D in both eyes. According to the World Health Organization, myopia is classified, based on SER power, as Low > -3 D, Medium -3 to -5 D, and finally High ≤ -5 D.[2] Patients with high myopia, typically having an axial length (AL) ≥ 26 mm, are at a higher risk of experiencing decreased visual acuity in adulthood; as a result of myopic maculopathy, retinal detachment, and glaucoma. [3,4] The number of high myopic persons in the world was estimated to be 170 million (2.8%) in 2015. There is an alarming overprediction of 1 billion (9.8%) of them in 2050. [2]

Classic ophthalmic textbooks have shown a description of the normal eye growth by Sorsby and Larsen (1961 and 1971).[5,6] Those studies estimated that after a decade of elongation in the first years of life, a deceleration occurs, with a presupposed stabilization of AL around 13-15 years old.[5,6] A similar result was found in an American study of emmetropic children (Zadnik et al. 2004).[7] Recent longitudinal studies using an interferometer-based measuring method have been successful in different populations. This method is more accurate than the ultrasonic method.[8,9] The renowned Shih et al. study conducted in 2009, involving over 11000 Taiwanese school-aged children, Jones et al. study of 2005 in the USA, and Tideman et al study conducted in European populations in 2018, all demonstrated a distinct axial growth pattern in myopic populations both before and after 13 years old.[10-12] There are only a few longitudinal studies attempting to evaluate axial growth among adults. [13-15] Some of them had myopic axial growth larger than hyperopic.[14] Other studies did not find a significant difference, even though they had a tendency to myopia shift.[16]

The factors associated to AL growing are genetic and environmental. Furthermore, there are many studies regarding the influence of environmental factors on myopia development.[17-22] The environmental factors include a lack of outdoor activities and an excess of near-work. There are some studies that showed the positive association between myopia and level of education.[23-25] Since the university students are an example of a population with high educational demands, especially the use of near vision, this study was proposed to investigate the refraction and the changing ocular biometric parameters during a two-year in these adult subjects, represented by students of medical university from Centro Universitário de Várzea Grande, Várzea Grande, Brazil (UNIVAG-MT).

3. Materials and Methods

3.1 STUDY DESIGN AND SETTING

This paper reported the two-year longitudinal data of subjects who were evaluated at the ophthalmology outpatient clinic at Oftalmocenter Santa Rosa in Cuiabá, Brazil. The SER is calculated as sphere + ½ cylinder power.

3.2 SAMPLE

All the medical students in their first to sixth semesters at UNIVAG (classes 2018-1, 2018-2, 2019-1, 2019-2, 2020-1, 2020-2), ages 17 to 30, were invited.

3.3 THE INCLUSION AND EXCLUSION CRITERIA

University students with a Snellen corrected visual acuity ≥ 0.66 in both eyes and a normal ophthalmologic examination were included. Those who have associated ocular pathologies, with incomplete data, who did not answer the questionnaire, with astigmatism ≥ 2 D or topographic irregular astigmatism, allergic to any cycloplegic drug, patients with syndromes that interfere with the eye, such as Stickler, Marfan, Noonan, and Down syndrome, and those who did not agree or sign the written informed consent, were excluded.

3.4 ETHICAL CONSIDERATIONS

All students who participated in the study were provided with an orientation and those who agreed to participate in the study were required to sign a written informed consent. The collected data were saved confidentially, and no individual information was obtained. The ethical approval was obtained from Comitê de ética em pesquisa da UNIVAG – MT, number 4.566.016, on March 1st, 2021. The study was registered in the Plataforma Brasil program – CAAE: 40738620.1.0000.5692.

3.5 DATA COLLECTION PROCEDURES

The ophthalmological examination included the evaluation of Snellen visual acuity, the measurement of static refraction with the use of an autorefractor (Canon®, USA) under cycloplegia, with prior administration of 0.5% proparacaine, followed by one application of 1% cyclopentolate eye drops, and two applications of 1% tropicamide, one drop each, with 5 min intervals between drops. The anterior segment was examined through biomicroscopic in slit lamp, tonometry (Tono-pen®, USA), cover test, corneal topography, and optical biometry (Lenstar LS900®, Haag-Streit, USA). The lens power was calculated indirectly using Bennett and Rozema's formula, using the cycloplegic refraction, K_1, K_2, anterior chamber depth, lens thickness and AL.[26] The same exams were performed again two years later. The selected students answered a questionnaire about outdoor and near-work activities during the last evaluation.

3.6 DATA ANALYSIS

Statistical analyses were performed using SAS/STAT software, V.9.4 of the SAS system for Windows.

Descriptive statistics were used to describe the data from measurements of visual acuity and SER for both eyes. Conversely, measurements of the corneal keratometry, biometry and lens power were registered only for the right eye. The Shapiro-Wilk test was performed for analyzing normality, and the paired t-test students to compare two years follow-up. All tests were considered significant when $p < 0.05$.

4. Results

Of the one hundred and twenty-eight university students who were eligible in the first exams, eighty-nine completed the two-year follow-up. The mean age at baseline was 21.00 ± 1.92 years. Thirty-seven (41.57%) participants were males and 52 (59.43%) were females. Regarding refractive errors, 11 (12.36%) were hyperopic, 28 (31.46%) were emmetropic, 45 (50.56%) were myopic and 5 (5.61%) were high myopic. The mean and standard deviation (SD) of the SER, the anterior chamber depth, the lens thickness, the AL, the mean keratometries (K_m), and the powers of the lens of the total and in each refractive error were described in Table 1 and 2. No significant two-year change in K_m was found in any of the subgroups (Figure 1).

Table 1. Mean and SD of principal linear variables

Parameter	Mean	Standard deviation
Age (year)	21.00	1.92
Spherical equivalent (D)	-1.33	2.12
Keratometry (D)	43.44	1.36
Anterior chamber depth (mm)	3.81	0.26
Lens thickness (mm)	3.49	0.17
Axial length (mm)	24.24	1.11
Lens power (D)	22.19	1.74

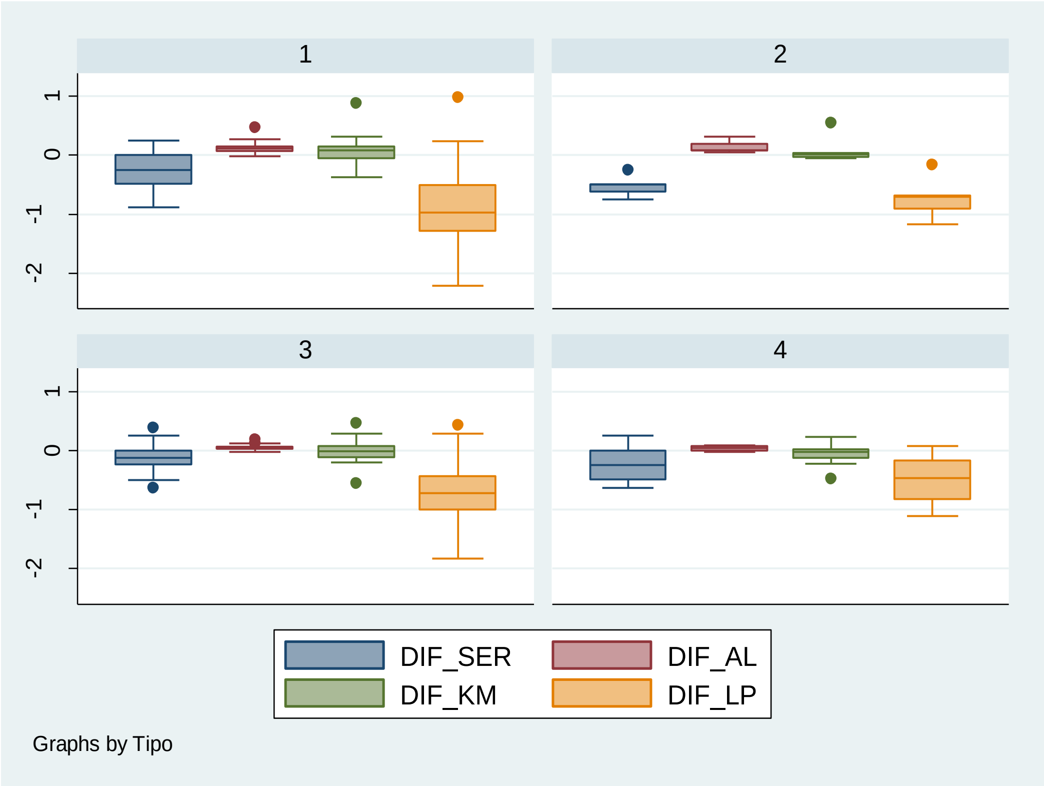
The average of hours per day spent in outdoor activities was 1.36 ± 0.8 h. The spent near-work activities were on average 8.66 ± 1.77 h. The mean and SD in outdoor and near-work activities for each refractive error group were described in Table 3.

Approximately 42% of myopic, 40% of high myopic, 3.6% of emmetropic, and no hyperopic students had an AL growth greater than 0.06 mm/year. There were small differences in the rate of SER change between emmetropes and myopes that did not reach statistical significance (p=0.129), while there were significant differences in AL growth between these emmetropic and myopic groups (p<0.001). Although the lens lost more power in myopic subjects during this two-year period, the difference in lens power loss was not significant when compared to that of emmetropes (p=0.237). Interestingly as can be seen in table 2, the lens power was highest at baseline or follow up in hyperopes and lowest in high myopes (p<0.001).

Table 2. Mean and SD initial and final parameters of all and each refraction group

Parameter	Total	Hyperopic	Emmetropic	Myopic	High Myopic
	89	**11**	**28**	**45**	**5**
Age (years)	21.00 ± 1.92	21.18 ± 2.93	21.04 ± 1.71	21.00 ± 1.86	20.40 ± 1.34
Spherical equivalent (D)					
SER 1	-1.33 ± 2.12	0.99 ± 0.21	0.13 ± 0.28	-2.19 ± 1.25	-6.85 ± 2.21
SER 2	-1.55 ± 2.21	0.76 ± 0.40	0.00 ± 0.28	-2.42 ± 1.33	-7.38 ± 2.24
Valor p	***<0.0001***	***0.0231***	***0.0042***	***<0.0001***	***0.0032***
Keratometry (D)					
KM 1	43.44 ± 1.36	43.48 ± 1.43	43.31 ± 1.27	43.40 ± 1.36	44.52 ± 1.65
KM 2	43.46 ± 1.38	43.41 ± 1.40	43.30 ± 1.37	43.45 ± 1.35	44.62 ± 1.45
Valor p	***0.3682***	***0.2332***	***0.6918***	***0.0759***	***0.4282***
Axial length (mm)					
AL 1	24.24 ± 1.11	23.19 ± 0.61	23.69 ± 0.74	24.64 ± 0.94	26.04 ± 1.23
AL 2	24.33 ± 1.14	23.23 ± 0.62	23.73 ± 0.74	24.76 ± 0.96	26.18 ± 1.28
Valor p	***<0.0001***	***0.0223***	***<0.0001***	***<0.0001***	***0.0460***
Lens power (D)					
LP 1	22.19 ± 1.74	22.67 ± 1.03	22.43 ± 1.66	22.02 ± 1.82	21.18 ± 2.54
LP 2	21.41 ± 1.70	22.17 ± 1.12	21.72 ± 1.66	21.14 ± 1.66	20.45 ± 2.61
Valor p	***<0.0001***	***0.0019***	***<0.0001***	***<0.0001***	***0.0122***

Figure 1: Box-Plot comparing changes in two-year follow-up of refraction and biometric parameters in initial refraction error category.



1- Myopic, 2- High myopic, 3- Emmetropic, 4- Hyperopic. DIF_SER: difference between initial and finals spherical equivalent refraction, DIF_AL: difference in axial length, DIF_KM: difference in keratometry mean, DIF_LP: difference in lens power.

Table 3. Hours of activities per day of each refraction group

Hours per day	Hyperopic	Emmetropic	Myopic	High Myopic
Outdoor activities	1.00 ± 0.55	1.15 ± 0.65	1.43 ± 0.95	1.71 ± 0.57
Near-work activities	9.00 ± 1.36	8.00 ± 1.84	8.43 ± 1.83	8.29 ± 1.98

5. Discussion

The literature shows that biometric measurements of myopic eyes in adulthood are different from those of emmetropic and hyperopic eyes.[10,15] This study demonstrated that myopic eyes had a greater impact on AL and lens power than emmetropic and hyperopic eyes during a follow-up period in early adulthood. This finding is in agreement with the results of some previous longitudinal studies.[10,15] Different to this picture, the classic study by Sorby showed no growth of AL in his patients over the age of 13. Nonetheless, they utilized a calculated method for the AL, and the participants did not possess a high education level. They also incorporated all refractive errors together. [5] In addition, the classic Zadnic et al. study met an annual variation of 0.02 mm in patients emmetropic between 11 and 14 years old. Everything suggests that some previous justifications exposed have been repeated in this one.[6] In contradiction, Hagen et al. in 2019 reported variations in AL of 0.05 mm/year in a population aged between 16 to 18 years old.[27] This last study demonstrated that emmetropic individuals continue to exhibit some ocular growth at an average age of 20 years. However, there was no refractive myopization in that study because there was compensation with decreasing lens power.[27] A Chinese longitudinal study showed that there was no change in lens power among university students, even though 92.40% of them were myopic. The present study used Bennett and Rozema's formula and lens thickness to calculate the lens power. The mean lens power in the myopic population was 22.02 ± 1.82 D, which was approximately identical to the findings of the Chinese study (22.76 ± 1.60 D).[28] The indirect method was used because there was no accurate device for measuring lens power. The precision of Bennett's formula is contingent upon the reliability of the measurements of the biometric parameters incorporated within the formula.[26,29]

The myopic group in this study had an AL of 0.08 mm higher than emmetropic and hyperopic students. The Shih et al. study reported in 2009 showed greater difference (1.7 mm) between myopic and emmetropic in young adult populations.[10] Interestingly, the emmetropic population had almost the same AL value shown for the Asian population cited.[10]

Studies conducted on individuals exposed to prolonged near-work activities showed myopia progression in adulthood.[30,31] In this study, an elevated level of near-work was found (8.66 ± 1.77 h) according to the questionnaire applied. There is some uncertainty about whether the questionnaire can underestimate the time spent in near-work activities, because there is a general cultural knowledge about this, and the population tends to underestimate this result. It has been confirmed in a comparative study using an objective method to measure the near-work time and compare it with the result of the questionnaire applied.[32]

Importantly noted, the lens power may change as a result of lens thickness variation or index refraction variation, which may happen for different patterns of new fiber growth in the crystalline lens. This paper showed that even at early adult years there was some compensation of ocular growth by lens power loss. Cross-sectional data herein indicated that myopic eyes exhibit lower lens power, a condition probably developed early in life that compensates in part the greater axial elongation found in myopic eyes.[33] Although this study found greater loss of lens power in the follow up in myopic eyes compared to emmetropes, this difference did not reach statistical significance. Hope this study is replicated in the future with biometry in larger samples.

The choice of thresholds point for high myopia was crucial in the present study. The World Health Organization – WHO - defines high myopia as <-5 D, however, currently, the International Myopia Institute - IMI – considers it to be <-6 D.[2,34] If this study had considered just < -6 D, we would have let 3 participants out of data from high myopia, but two of them already met an AL higher than 26 mm (26.19 and 27.28 mm), which is the main risk factor for the development of vision-threatening linked complications.[35-38]

It needs to be noted, however, that the study has some limitations. First, the number of participants in each refractive error subgroup was small. Second, this study was conducted for only 2 years, and it would have been better if we had conducted it for 5 years or more.

6. Conclusions

This longitudinal study of changes in SER and ocular biometric parameters involving subjects of 18 to 26 years of age, students of a high-performing education system, showed continued ocular axial growth in some myopic and emmetropic case. A stable SER was maintained by a coordinated decrease in lens power, suggesting that lens development may play a pivotal role in protecting against myopia. Studies in other cities and involving larger numbers of participants could help to find the natural history evolution of myopia in medical university students from Brazil.

7. Conflicts Of Interest Statement

The authors declare no conflict of interest, financial or otherwise.

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