Influence of Intensive Near-work on Refractive, Biometric and Topographic Changes in Last Year Portuguese Medical Students: One-year Longitudinal Study

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ABSTRACT

Purpose: To analyze the refractive, biometric and topographic changes in last year Portuguese medical students exposed to high educational demands.

Methods: One-year longitudinal cohort study was performed. Data collected consisted in ocular refraction, axial length (AL), keratometry, corneal thickness, macular thickness and volume. Ophthalmological evaluations were performed 6 months before the students' final exam, one month after the exam and 6 months later.

Results: Twenty-five medical students were included. The mean spherical equivalent was -1,57 ± 1,29 D at the 1st visit, -1,73 ± 1,44 D in the 2nd visit and -1,40 ± 1,39 D in the 3rd visit. No statistical significant differences were observed in the mean spherical equivalent between the 1st and 2nd visits (p=0,055) and between the 1st and 3rd visits (p=0,331).
In the 1st, 2nd and 3rd visits, the AL was 23,91 ± 0,99 mm; 24,01 ± 0,98 mm and 23,94 ±1,03 mm, respectively. The AL increased significantly between the 1st and 2nd visits (p<0,001), but the variation between the 1st and 3rd visits was not significant (p=0,414). Corneal thickness and posterior surface corneal keratometry in the steepest axis decreased significantly at the 2nd visit (p<0,05). Macular thickness and volume variation during the follow-up were not statistically significant (p>0,05).

Conclusions: This study failed to show statistically significant changes in refraction towards myopia in Portuguese medical students after a long period of near-work; nonetheless the small sample size may have contributed to the lack of statistical significance. The refractive values returned to baseline after 6 months.

Key-words: myopia; near-work; refractive error; biometric parameters; corneal topography.

RESUMO

Objetivo: Analisar as alterações refrativas, biométricas e topográficas, em estudantes de medicina Portugueses, no último ano da faculdade, expostos a um elevado nível de exigência académica durante o estudo para o exame de acesso à formação específica.

Métodos: Estudo coorte longitudinal com a duração de um ano. Foram obtidos dados relativos à refração ocular, comprimento axial, queratometria, espessura da córnea em diferentes pontos, assim como, espessura e volume da mácula. Os exames oftalmológicos foram realizados 6 meses antes do exame de acesso à formação específica, repetidos 1 mês depois e, por fim, 6 meses após o exame.

Resultados: Vinte e cinco estudantes de medicina foram incluídos. Inicialmente, o valor médio do equivalente esférico foi -1,57 ± 1,29 dioptrias (D). Na 2ª visita, foi -1,73 ± 1,44 D e, na 3ª visita, foi -1,40 ± 1,39 D. Não se observaram diferenças estatisticamente significativas no equivalente esférico entre a 1ª e 2ª visitas (p=0,055) e a 1ª e 3ª visitas (p=0,331). Na 1ª, 2ª e 3ª visita o comprimento axial foi 23,91 ± 0,99 mm; 24,01 ± 0,98 mm e 23,94 ±1,03 mm, respetivamente. O aumento do comprimento axial entre a 1ª e a 2ª visitas foi estatisticamente significativo (p<0,001). Contudo, entre a 1ª e a 3ª visitas, a sua variação não foi significativa (p=0,414). A espessura da córnea e a queratometria no eixo mais curvo da superfície posterior da córnea, diminuíram significativamente entre a 1ª e a 2ª visitas (p<0,05). Não se verificou uma variação estatisticamente significativa na espessura e no volume da retina na região foveal e parafoveal durante o período de seguimento.

Conclusão: Não foi possível demonstrar uma miopização significativa nos estudantes de medicina portugueses após um longo período de estudo. A ausência de significância estatística pode ter sido condicionada pelo tamanho limitado da amostra. Os valores do estado refrativo após 6 meses de suspensão do estímulo acomodativo reverteram para valores semelhantes aos iniciais.

Palavras-chave: miopia; trabalho ao perto; erro refrativo; biometria; topografia da córnea.

INTRODUCTION

Uncorrected refractive errors are one of the major causes of potentially reversible blindness and also represent an economic burden worldwide.[1] The prevalence of myopia is increasing at a startling rate and the World Health Organization estimates that, by the year 2050, 52% of the world population will have myopia.[2]

The aetiology of myopia is far from being clear. The classical belief that the eye reaches its adult size by the age of 13-14 years was supported for a long time.[3] For this reason, many argued that there was no significant change in the refractive state of the eye after this age. However, recently, many environmental and biological factors have been identified as risk factors for myopia progression after that period.[4-6] Among the environmental factors, educational level and time spent in near-work activities are risk factors for myopia development.[7] Otherwise, time spent in outdoor activities has a possible protective effect on myopia progression.[4,8] Although genetic factors may partly explain the risk of developing myopia, they cannot explain the change in refraction towards myopia after an intensive near-work effort.[9]

University students assemble several characteristics that potentiate the development of adult-onset myopia or adult progression of myopia.[10,11] Wei S *et al* evaluated the prevalence of refractive errors among the university students of Anyang, in China, finding that 83,2% of the students had myopia (spherical equivalent ≤ -0,50 D) and 11,1% high myopia (spherical equivalent ≤ - 6,0 D).[12] J. Jorge *et al* investigated the variation of refractive errors and biometric ocular parameters during a 3-year period, among a group of 118 Portuguese university students (mean age of 21 years). At the beginning of the study, the spherical equivalent was 0,23 ± 1.46 D and that changed to -0,29 ± 0.38 D at the end of the follow-up period ($p < 0.001$).[10]

Portuguese medical students represent a specific group of university students who spend a lot of time in intensive near-work. In their last year, these students have a final examination that requires a long period of preparation and many students start studying, approximately, six to twelve months before with a daily near-work period of at least 8 hours. The great majority of students suspend their leisure activities and spend most of their time studying. Considering that, this group of students have a higher risk of myopia development.[11]

The purpose of this study was to evaluate the refractive, biometric and topographic changes in the last year Portuguese medical students after a long period of intensive near-work and to determine the reversibility of these changes 6 months later.

METHODS

Study design: This is a prospective longitudinal single-center study performed in the North of Portugal between January and December of 2018. Refractive, biometric and topographic measures were acquired six months before the medical students' final exam (1st visit), up to one month after that (2nd visit) and four to six months after the final exam (3rd visit). The time of visits for ocular examination is related to different periods of study intensity.

Informed written consent was obtained from all participants. The present study was approved by the Ethics Committee of Centro Hospitalar Universitário de São João and it was developed in conformity with the Declaration of Helsinki.

Study population: Forty students were initially enrolled in this study. Fifteen students were lost to follow-up. Therefore, the final population included twenty-five Portuguese students in the last year of medicine master's degree in the Faculty of Medicine of Porto, in Portugal.

Inclusion criteria were: subjects that started to study for the final exam six months before the medical students' final exam and that planned to continue to study until that date; and good cooperation to obtain successful refractive, biometric and topographic measurements.

Exclusion criteria were: evidence of any eye disease like high myopia, defined as spherical equivalent ≤ -5,0 D; anisometropia, defined as a spherical equivalent difference ≥ 2,0 D between the two eyes; previous history of ocular injury or surgery; other ocular pathology (such as cataract, keratoconus, leucoma and retinal diseases) or condition that interferes with the refractive, biometric and topographic measurements.

Data collected: The baseline and follow-up measurements included were: automated refraction measures - sphere (S), cylinder (C) and axis; anterior segment measures - anterior chamber depth (ACD) and anterior chamber volume (ACV); axial length (AL); keratometry measures: anterior and posterior surface' corneal powers in the flattest axis (K1A and K1P) and in the steepest axis (K2A and K2P), the maximum corneal power (KM), the medium corneal power (KmA and KmP) and the anterior and posterior surface' corneal astigmatism power (AstigmA and AstigmP); corneal thickness measured in the apex (ACT) and in the pupil area (PCT); minimal corneal thickness (MCT), corneal volume (CV); and sub and parafoveal retinal thickness and subfoveal macular volume. All the measurements were not acquired under cycloplegia.

Like other studies, we also consider myopia if it comprised a spherical equivalent ≤- 0.50 D, emmetropia a spherical equivalent between - 0.50 D and + 0.50 D and hyperopia a spherical equivalent ≥+0.50 D.[10,12,13] The genetic component associated with the development and evolution of myopia has not been evaluated.

Materials

Noncycloplegic refraction measures were made using the ARKM-200 Tagaki Seiko autorefractometer. Anterior segment of the eye and axial length measurements were collected using the IOLMaster® 500 (Carl Zeiss Meditec, Jena, Germany). Keratometry and corneal thickness were assessed using the Pentacam® HR (Oculus, Wetzlar, Germany). Retinal thickness and volume were acquired with spectral-domain optical coherence tomography (SD-OCT, Heidelberg Engineering, Heidelberg, Germany).

Automatic refractometer (ARKM-200 Takagi Seiko, Japan): ARKM-200 is an automatic refractometer. The refraction is calculated by using sensors that detect the reflections from a cone of infrared light. These reflections are used to determine the size and shape of a ring in the retina. By measuring this zone, the autorefractor can determine when a patient's eye properly focuses an image. The instrument changes its magnification until the image comes into focus. The process is repeated in at least three meridians of the eye and the autorefractor calculates the refraction of the eye, sphere, cylinder and axis.

IOLMaster® 500 (Carl Zeiss Meditec, Jena, Germany): IOLMaster 500 is a partial coherence interferometer used for anterior segment and AL measurements. It measures the anterior corneal keratometry (mean of three measurements), using the data from six light reflections (590 nm) oriented in a hexagonal pattern approximately 2.3 mm diameter, and the AL (mean of five measurements) through an infrared light (780 nm). These parameters, which are fundamental for IOL power calculation and implantation, have been shown to have a high intra and interobserver reproducibility.[14,15]

Pentacam® HR (Oculus, Wetzlar, Germany): Pentacam uses a single rotating Scheimpflug camera and a monochromatic slit-light source (blue LED at 475 nm) combined with a static camera to generate a three-dimensional high-resolution image of the anterior segment. In less than 2 seconds, the 180-degree rotating camera captures up to 25 slit images of the anterior segment, collecting 25 000 true elevation points. Any eye movement is detected by the static camera and corrected for in the process. The anterior corneal keratometry measurements have been shown to have excellent repeatability and reproducibility.[16,17]

Spectralis OCT, Heidelberg (Heidelberg Engineering, Heidelberg, Germany): SD-OCT is a spectral-domain (also called Fourier-domain) system that allows high-speed, high-resolution cross-sectional imaging of the retina. OCT imaging can be single cross sections of the retina ("B-scans"), patterns of single cross sections, or complete three-dimensional images. The beam of a super luminescent diode (SLD) scans across the retina to produce a cross sectional B-scan image. To create three dimensional images of the retina, up to 768 equally spaced B-scans can be sequentially acquired. The infrared beam of the SLD has an average wavelength of 870 nm.[18]

The SD-OCT imaging acquisition protocol included a high quality horizontal 6 mm scan centered on the fovea. In the retinal thickness map, data were grouped in 9 macular sectors within 3 concentric circles as defined by the Early Treatment Diabetic Retinopathy Study (ETDRS) with 1, 3 and 6 mm of diameter. The central circle (1mm) represents the central foveal area (C). The second circle (3mm) is subdivided into superior, nasal, inferior and temporal parafoveal retinal areas. The third circle (6mm) is subdivided into superior, nasal, inferior and temporal perifoveal retinal areas. In our study, we collected data about retinal thickness in 1 mm and 3 mm rings and retinal volume in 1mm ring. All the examinations were performed between 11 am and 3 pm.

Statistical analysis

Statistical analysis was performed using the SPSS® statistical software (version 25.0 for Windows; SPSS Inc., Chicago, IL., USA). Normal distribution was checked using Kolmogorov- Smirnov Test. Parametric or non-parametric tests were used for continuous variables comparison, according to the normality of data. The level of significance was established at $p < 0.05$. Only right eye data were used. There was no significant difference between the mean refractive error of the right eye versus left eye.

RESULTS

Forty students were initially enrolled in this study. Fifteen students were lost to follow-up. A total of 25 students, 5 males and 20 females were included in this study. The mean age was 24,44 ± 3,06 years, ranging from 22 to 35 years.

Refractive error

Between the 1st and 2nd visit, 3 (12%) students presented a spherical equivalent variation superior or equal to -0,50 D. Two of them had a variation equal to -0,63 D, corresponding to the maximum spherical equivalent difference observed in this period. Five (20%) students presented a spherical equivalent variation between -0,25 D and -0,50D.

Between the 1st and 3rd visit, 2 (10,6%) students had a spherical equivalent variation superior to -0,25 D. In 13 (68,4%) students, the spherical equivalent variation was between -0,25 D and 0,25 D (Table 1).

In the 1st, 2nd and 3rd visits, the mean spherical equivalent was -1,57 ± 1,29 D, -1,73 ± 1,44 D and -1,40 ± 1,39 D, respectively (Table 2). There was no significant variation between the spherical equivalent in the 1st and 2nd visit (p=0,055) and in the 1st and 3rd visit (p=0,331).

In the end of this study, none of the students needed to update their prescription glasses.

Table 1 - Difference of spherical equivalent values between 1st and 2nd and 1st and 3rd visits.

		1st and 2nd visit	**1st and 3rd visit**
Difference of spherical equivalent intervals	≤ -0,50 D	**n (%)**	**n (%)**
	]-0,50; -0,25[D	3 (12,0)	1 (5,3)
	[-0,25; 0,25] D	5 (20,0)	1 (5,3)
	]0,25; 0,50] D	11 (44,0)	13 (68,4)
	>0,50 D	1 (4,0)	2 (10,5)
	≤ -0,50 D	0	2 (10,5)
Total		20 (100,0)	19 (100,0)

Table 2 - Refractive components obtained in the three visits and statistical significance of variations between 1st and 2nd visit and 1st and 3rd visit. The level of significance was established at p <0.05.

	Mean ± SD (minimum – maximum)			**p-value**	
	1st visit	**2nd visit**	**3rd visit**	**1st visit and 2nd visit**	**1st visit and 3rd visit**
Sphere power (D)	-1,29 ± 1,23 (-4,00 to 0,25)	-1,43 ± 1,36 (-4,50 to 0,00)	-1,13 ± 1,32 (-4,00 to 0,50)	0,116	0,331
Cylinder power (D)	-0,57 ± 0,39 (-1,25 to 0,00)	-0,61 ± 0,53 (-1,75 to 0,00)	-0,56 ± 0,46 (-1,25 to 0,25)	0,499	0,796
Spherical Equivalent (D)	-1,57 ± 1,29 (-4,25 to -0,13)	-1,73 ± 1,44 (-4,63 to -1,25)	-1,40 ± 1,39 (-4,25 to 0,13)	0,055	0,331

Biometric measures

Mean values of biometry, corneal topography and keratometry during follow-up are shown in Table 3.

At the beginning of the study, the AL was 23,91 ± 0,99 mm and, at the 2nd visit, was 24,01±0,98 mm (p<0,01). At the 3rd visit, the AL was 23,94 ± 1,03 mm (p=0,414).

Anterior chamber depth (ACD), measured with both IOLMaster® 500 and Pentacam® HR, did not change significantly during the follow-up.

Table 3 - Biometry, Keratometry and Pachymetry measures obtained with IOLMaster® 500 (*) and Pentacam® HR (**), in the three visits and statistical significance of variations between 1st and 2nd visit and 1st and 3rd visit. Biometry measures: anterior chamber depth (ACD); anterior chamber volume (ACV); axial length (AL) and corneal volume (CV). Keratometry measures: corneal powers in the flattest and in the steepest axis with IOLMaster® 500 (K1 and K2), anterior and posterior surface' corneal powers in the flattest axis (K1A and K1P) and in the steepest axis (K2A and K2P), the maximum corneal power (KM), the medium corneal power (KmA and KmP) and the anterior and posterior surface' corneal astigmatism power (AstigmA and AstigmP). Pachymetry measures: corneal thickness measured in the apex (ACT) and in the pupil area (PCT); minimal corneal thickness (MCT). The level of significance was established at p <0.05.

	Mean ± SD (minimum – maximum)			**p-value**	
	1st visit	**2nd visit**	**3rd visit**	**1st visit and 2nd visit**	**1st visit and 3rd visit**
Biometry					
AL* (mm)	23,91± 0,99 (22,62 to 25,67)	24,01 ± 0,98 (22,73 to 25,74)	23,94 ± 1,03 (22,59 to 25,79)	<0,01	0,414
ACD* (mm)	3,54 ± 0,30 (2,99 to 3,87)	3,60 ± 0,24 (3,06 to 3,86)	3,62 ± 0,24 (3,06 to 3,86)	0,165	0,185
ACD** (mm)	3,16 ± 0,26 (2,48 to 3,51)	3,15 ± 0,28 (2,46 to 3,56)	3,16 ± 0,25 (2,48 to 3,51)	0,665	0,829
ACV** (mm3)	188,42 ± 26,00 (118 to 234)	188,67 ± 27,28 (117 to 230)	188,28 ± 27,51 (117 to 224)	0,787	0,853
CV** (mm3)	60,52 ± 3,98 (53,70 to 67,40)	60,30 ± 3,54 (53,80 to 65,30)	61,44 ± 3,41 (55,70 to 67,20)	0,042	0,290
Keratometry					
K1* (D)	43,13 ± 1,38 (40,81 to 44,64)	43,10 ± 1,41 (40,66 to 44,58)	43,15 ± 1,42 (40,91 to 44,64)	0,066	0,051
K2* (D)	44,14 ± 1,54	44,02 ± 1,53	44,16 ± 1,40	0,063	0,817

	(41,56 to 46,23)	(41,11 to 45,98)	(41,77 to 46,04)		
K1A** (D)	42,53 ± 1,51 (39,80 to 44,50)	42,63 ± 1,46 (39,90 to 44,40)	42,93 ± 1,17 (40,70 to 44,50)	0,633	0,583
K2A** (D)	43,45 ± 1,47 (41,10 to 45,60)	43,55 ± 1,42 (41,10 to 45,50)	43,92 ± 1,23 (41,40 to 45,70)	0,416	0,035
KmA** (D)	42,98 ± 1,47 (40,60 to 45,00)	43,08 ± 1,42 (40,70 to 44,80)	43,42 ± 1,15 (41,10 to 45,10)	0,708	0,068
AstgimA** (D)	0,93 ± 0,54 (0,00 to 1,90)	0,92 ± 0,51 (0,10 to 2,10)	0,99 ± 0,54 (0,00 to 2,00)	0,767	0,108
K1P** (D)	-6,08 ± 0,24 (-6,40 to -5,60)	-6,11 ± 0,23 (-6,40 to -5,70)	-6,17 ± 0,18 (-6,40 to -5,90)	0,705	0,719
K2P** (D)	-6,38 ± 0,27 (-6,80 to -5,90)	-6,43 ± 0,24 (-6,80 to -5,90)	-6,48 ± 0,23 (-6,80 to -6,10)	0,028	0,301
KmP** (D)	-6,22 ± 0,24 (-6,50 to -5,70)	-6,27 ± 0,23 (-6,60 to -5,80)	-6,32 ± 0,21 (-6,60 to -6,00)	0,056	0,271
AstgimP** (D)	0,28 ± 0,09 (0,10 to 0,40)	0,31 ± 0,11 (0,10 to 0,50)	0,32 ± 0,12 (0,10 to 0,50)	0,033	0,035
KM** (D)	43,96 ± 1,52 (41,30 to 46,20)	44,09 ± 1,47 (41,40 to 46,30)	44,39 ± 1,29 (41,90 to 46,40)	0,307	0,461
Pachymetry					
PCT** (µm	538,68 ± 33,83 (492 to 627)	535,67 ± 31,53 (494 to 612)	544,44 ± 30,92 (497 to 612)	<0,001	0,077
ACT** (µm)	539,37 ± 32,86 (493 to 625)	536,76 ± 30,93 (493 to 610)	544,72 ± 30,48 (498 to 611)	<0,001	0,057
MCT** (µm)	534,21 ± 34,36 (489 to 624)	532,14 ± 32,44 (478 to 610)	541,44 ± 30,74 (496 to 610)	<0,001	0,632

Corneal topography and keratometry

In the 1st visit, PCT was 538,68 ± 33,83 µm, ACT was 539,37 ± 32,86 µm and MCT was 534,21 ± 34,36 µm. When compared to baseline and the 2nd visit, the corneal thickness decreased significantly in the three measured points (apex, pupil and minimal corneal thickness) (p<0,001) (Table 3).

The corneal keratometry measured in the anterior corneal surface did not change significantly during the follow-up (p>0,05). Otherwise, the corneal keratometry in its steepest axis measured in the posterior corneal surface (K2P) changed significantly (p= 0,028) between baseline (-6,38 ± 0,27 D) and second examination (-6,43 ± 0,24 D). The corneal astigmatism measured in the posterior surface (AstigmP) increased +0,03 D between the 1st (0,28 ± 0,09 D) and 2nd visits (0,31 ± 0,11 D) and this variation was statistically significant (p=0,033). Regarding keratometry evaluation between the 1st and 3rd visits, no statistically significant changes were observed.

Corneal volume (CV) decreased significantly between the 1st visit (60,52 ± 3,98 mm^3) and the 2nd visit (60,30 ± 3,54 mm^3) (p=0,042).

Retinal thickness

At the beginning of the study, the subfoveal retinal thickness was 264,71 ± 15,71 µm. In the parafoveal area, the retinal thickness was 337,64 ± 25,26µm in the superior sector, 340,79 ± 17,89 µm in the nasal sector, 326,14 ± 17,45 µm in the temporal sector and 337,86 ± 16,27 µm in the inferior sector. No statistically significant changes were observed in these variables during follow-up (p>0,05). The baseline subfoveal volume was 0,21 ± 0,01mm^3 and it did not change significantly during follow-up.

DISCUSSION

This is the first prospective longitudinal study that analyses the refractive, biometric and topographic changes during a one-year period among Portuguese medical university students exposed to high educational demands. At the beginning of the study, the spherical equivalent was -1,57 ± 1,29 D and, in the 2nd visit, it was -1,73 ± 1,44 D (p=0,055); however this did not quite reach statistical significance. This could have occurred due to the sample size and the important number of people lost to follow-up.

In fact, Jiang *et al*, evaluated a group of optometric students during their first academic year and found that the rate of myopic progression was superior during school period comparing to vacation period.[19] Kinge *et al* also observed a significantly mean spherical equivalent change of -0,51±0,49 D towards myopia in Norwegian university students after 3 years of follow-up.[2] On the other hand, Onal *et al.* did not find a statistically significant change in the refractive status among 207 medical students during one year.[11]

In our study, we observed a statistically significant increase of 0,10 mm in AL between the baseline and the 2nd visit. This increase in length returned to baseline values after the rest period. Based on previous studies that suggested that the final AL of the eye is achieved before the twenties,[3,20] significant changes on the AL would not be expected in our study.[3,20] However, recently, some studies found an association between the time spent on near-work activities and elongation of the eye.[21] Woodman *et al* evaluated the AL, before and immediately after a continuous period 30 minutes of near-work, in 40 participants with a mean age of 23 years. The mean AL increased in 0.015 ± 0.019 mm ($p<0.001$) and, after a rest period, it returned to baseline values. The authors hypothesized that the AL variation was a result of a sustained accommodation, being reversible with the cessation of the stimulus.[21] This was similar to what happened in our studies. In our population, the changes led to small variations in the refractive error that failed to reach statistical significance; also, these changes were clinically irrelevant. Other studies also observed a statistically significant increase in AL, lens thickness and vitreous chamber depth in university students after 3 years of follow-up.[10,22] In our study, we believe that the increase in AL and the myopic shift were a result of mechanical forces induced by sustained accommodation.

We verified a statistically significant decrease in corneal thickness and volume, and a significant change in posterior surface corneal keratometry in its steepest axis and in the corneal astigmatism between the 1st and 2nd visits. These changes could be explained by the mechanical effect of the eyelids while reading in a downward gaze position.[13,23-25]

To our knowledge, this is the first study that evaluates the influence of intensive long term near-work in the retinal thickness. Previous studies evaluated the influence of short accommodation periods, 30 minutes, in retinal thickness.[26-28] Unfortunately, the results are not consensual. One study, demonstrated a small, but statistically significant, reduction in macular thickness after a stimulus of maximum amplitude of accommodation induced by moving a target until the subjects reported a blurring of the target.[27] A possible explanation for the macular thickness variation was the forward movement of the ora serrata due to ciliary muscle contraction.[27] By opposition, Woodman *et al* found no significant change in retinal thickness during a 30 minutes period of accommodative effort.[28] In our study, no changes were observed.

Our study has several limitations. First, it has a small sample size and an important number of losses to follow-up and missing values. In fact, in their final year of faculty, medical students are concerned about preparing for the final exam, which is why some students have missed subsequent assessments. Second, this study was conducted as a university-based investigation rather than a population-based investigation, thus, the prevalence of myopia and the myopic shift may be overestimated. Third, the absence of subjective and objective refraction under cycloplegia could interfere with the accuracy of the refractive error status evaluation. Cycloplegic refraction would be important to remove the component of accommodation spasm in these participants since they spent so many hours studying continuously and would make the refraction assessment far more reliable. However, we did not perform cycloplegia to lessen worry of medical students about the side effects related to pupillary dilation and cycloplegia. Naturally, the definition of myopia influences the prevalence of refractive errors. For instance, a cut-off of -0.25 D would give a higher prevalence of myopia. In the present study, we considered myopia if the spherical equivalent was ≤- 0.50 D, which is in agreement with other cross-sectional and longitudinal studies.[4,12,19] Therefore, it is very important to standardize the definition of myopia in order to be able to easily compare different studies. In addition, the effect of confounding factors like heritage, intelligence, personality, and diet on the refractive change were not considered. As known, an accommodative response is stimulated during near-work. In this process, the ciliary muscle contracts, the axial thickness of the lens increases, its diameter decreases, and its dioptric power increases.[29] Therefore, the evaluation of ciliary body (with ultrasound biomicroscopy and anterior segment OCT), the lens thickness (with anterior segment OCT or A-scan ultrasonography) and the lens curvature radius (with Pentacam HR System) would be interesting. However, we were not able to perform the aforementioned studies, but we would suggest that future investigation in this matter take in account these measures.

Nevertheless, this study has also several strengths. It was the first study that evaluated the refractive, biometric and topographic changes during a one-year period among last year Portuguese medical students exposed to high educational demands. The belief in a myopic shift after study to medical final exam was well known for many years. Until now, it only was based on medical students' opinion that described difficulties in distance vision after the final exam. Furthermore, the student sample included in this study is very homogeneous with respect to age, race, educational level, and academic abilities.

To conclude, this study failed to show a definitive change in refraction towards myopia in Portuguese medical students after a long period of near-work. In spite of this, as myopia is a condition with increasing prevalence especially among individuals with a higher level of education, understanding the pathophysiology of myopia in this group of individuals is essential for the development of control strategies. In the particular case of university students, we do not recommend the actualization of their contact lenses or eyeglasses immediately after this period of intensive near-work since this change is expected to be transient.

REFERENCES

1. Bourne RR, Stevens GA, White RA, Smith JL, Flaxman SR, Price H, et al. Causes of vision loss worldwide, 1990-2010: a systematic analysis. Lancet Glob Health 2013;1:e339-49.
2. Kinge B, Midelfart A, Jacobsen G, Rystad J. The influence of near-work on development of myopia among university students. A three-year longitudinal study among engineering students in Norway. 2000;78:26-9.
3. Fledelius HC. Ophthalmic changes from age of 10 to 18 years. A longitudinal study of sequels to low birth weight. III. Ultrasound oculometry and keratometry of anterior eye segment. Acta Ophthalmol (Copenh) 1982;60:393-402.
4. Pan CW, Ramamurthy D, Saw SM. Worldwide prevalence and risk factors for myopia. Ophthalmic Physiol Opt 2012;32:3-16.
5. Lyhne N, Sjolie AK, Kyvik KO, Green A. The importance of genes and environment for ocular refraction and its determiners: a population based study among 20-45 year old twins. Br J Ophthalmol 2001;85:1470-6.
6. Saw SM. A synopsis of the prevalence rates and environmental risk factors for myopia. Clin Exp Optom 2003;86:289-94.
7. Morgan IG, French AN, Ashby RS, Guo X, Ding X, He M, et al. The epidemics of myopia: Aetiology and prevention. Prog Retin Eye Res 2018;62:134-49.
8. Huang HM, Chang DS, Wu PC. The Association between Near Work Activities and Myopia in Children-A Systematic Review and Meta-Analysis. PLoS One 2015;10:e0140419.
9. Fricke TR, Jong M, Naidoo KS, Sankaridurg P, Naduvilath TJ, Ho SM, et al. Global prevalence of visual impairment associated with myopic macular degeneration and temporal trends from 2000 through 2050: systematic review, meta-analysis and modelling. Br J Ophthalmol 2018;102:855-62.
10. Jorge J, Almeida JB, Parafita MA. Refractive, biometric and topographic changes among Portuguese university science students: a 3-year longitudinal study. Ophthalmic Physiol Opt 2007;27:287-94.
11. Onal S, Toker E, Akingol Z, Arslan G, Ertan S, Turan C, et al. Refractive errors of medical students in Turkey: one year follow-up of refraction and biometry. Optom Vis Sci 2007;84:175-80.
12. Wei S, Sun Y, Li S, Hu J, Yang X, Lin C, et al. Refractive Errors in University Students in Central China: The Anyang University Students Eye Study. Investigative Opthalmology & Visual Science 2018;59:4691.
13. Shi XY, Ke YF, Jin N, Zhang HM, Wei RH, Li XR. The prevalence of vision impairment and refractive error in 3654 first year students at Tianjin Medical University. Int J Ophthalmol 2018;11:1698-703.
14. Shammas HJ, Chan S. Precision of biometry, keratometry, and refractive measurements with a partial coherence interferometry-keratometry device. J Cataract Refract Surg 2010;36:1474-8.
15. Vogel A, Dick HB, Krummenauer F. Reproducibility of optical biometry using partial coherence

interferometry : intraobserver and interobserver reliability. J Cataract Refract Surg 2001;27:1961-8.
16. Shankar H, Taranath D, Santhirathelagan CT, Pesudovs K. Anterior segment biometry with the Pentacam: comprehensive assessment of repeatability of automated measurements. J Cataract Refract Surg 2008;34:103-13.
17. Kawamorita T, Nakayama N, Uozato H. Repeatability and reproducibility of corneal curvature measurements using the Pentacam and Keratron topography systems. J Refract Surg 2009;25:539-44.
18. Aumann S, Donner S, Fischer J, Muller F. Optical Coherence Tomography (OCT): Principle and Technical Realization. In: Bille JF, ed. High Resolution Imaging in Microscopy and Ophthalmology: New Frontiers in Biomedical Optics. Cham (CH)2019:59-85.
19. Jiang B-C, Schatz S, Seger K. Myopic progression and dark focus variation in optometric students during the first academic year. Clinical and Experimental Optometry 2005;88:153-9.
20. Bhardwaj V, Rajeshbhai GP. Axial length, anterior chamber depth-a study in different age groups and refractive errors. J Clin Diagn Res 2013;7:2211-2.
21. Woodman EC, Read SA, Collins MJ, Hegarty KJ, Priddle SB, Smith JM, et al. Axial elongation following prolonged near work in myopes and emmetropes. Br J Ophthalmol 2011;95:652-6.
22. Kinge B, Midelfart A, Jacobsen G, Rystad J. Biometric changes in the eyes of Norwegian university students - A three-year longitudinal study. Acta Ophthalmologica Scandinavica 1999;77:648-52.
23. Collins MJ, Kloevekorn-Norgall K, Buehren T, Voetz SC, Lingelbach B. Regression of lid-induced corneal topography changes after reading. Optom Vis Sci 2005;82:843-9.
24. Buehren T, Collins MJ, Carney L. Corneal aberrations and reading. Optom Vis Sci 2003;80:159-66.
25. Niyazmand H, Ostadi Moghaddam H, Sedaghat MR, Ahmadi Hosseini SM, Abolbashari F. Anterior segment changes following short-term reading and its correlation with corneal biomechanical characteristics. Ophthalmic Physiol Opt 2013;33:592-6.
26. Ghosh A, Collins MJ, Read SA, Davis BA, Chatterjee P. Axial elongation associated with biomechanical factors during near work. Optom Vis Sci 2014;91:322-9.
27. Fan S, Sun Y, Dai C, Zheng H, Ren Q, Jiao S, et al. Accommodation-induced variations in retinal thickness measured by spectral domain optical coherence tomography. J Biomed Opt 2014;19:96012.
28. Woodman EC, Read SA, Collins MJ. Axial length and choroidal thickness changes accompanying prolonged accommodation in myopes and emmetropes. Vision Res 2012;72:34-41.
29. Wang K, Pierscionek BK. Biomechanics of the human lens and accommodative system: Functional relevance to physiological states. Prog Retin Eye Res 2019;71:114-31.

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