Myopia in Houston optometry graduates from 2013 to 2023

Barsha Lal, PhD,[1] Joshua Joseph, BS,[1] Amy Cantrell, BS,[1] Han Cheng, OD, PhD,[1] and Lisa A. Ostrin, OD, PhD, FAAO,[1]*

SIGNIFICANCE: Adult onset and progression of myopia are not well understood. It is of interest to better characterize myopia progression in young adults, who are frequently subjected to risk factors, such as intense near-work demands.

PURPOSE: This study aimed to assess the prevalence and progression of myopia and other refractive errors in optometry students in the United States.

METHODS: This study was a retrospective chart review of electronic medical records of students enrolled in the optometry program at the University of Houston College of Optometry who graduated between 2013 and 2023. For each student, refractive error was noted from the medical record for eye examinations during their time as an optometry student. Exclusion criteria were ocular disease, myopia control treatment, or refractive surgery. Prevalences of hyperopia (≥+0.50 D), emmetropia (>−0.50 to <+0.50 D), myopia (≤−0.50 D), astigmatism (>0.50 D), and anisometropia (≥1.0 D) were determined from spherical equivalent refraction (SER) of the right eye. Absolute and annualized differences in SER were calculated between visits.

RESULTS: Records for 1071 students were reviewed, and 961 were included. Prevalences were 80.7% for myopia, 14.9% for emmetropia, and 4.4% for hyperopia. Additionally, 38.4% had astigmatism, and 16.1% had anisometropia. Students with one follow-up exam (n = 639) showed a significant negative change in SER of −0.05 ± 0.38 D over an average follow-up period of 1.60 ± 0.61 years (p=0.001). Myopia onset was observed in 15.7% of emmetropes at baseline. Greater negative SER change was associated with greater follow-up duration and younger age. Hyperopes and emmetropes did not demonstrate significant changes in SER. An annualized negative SER change of ≥ −0.25 D was noted in 20% of the 639 students, of which 5.5% showed ≥ −0.50 D.

CONCLUSIONS: Findings demonstrate a high prevalence of myopia among optometry students. A small but statistically significant myopic change in refraction was observed. These findings may implicate a role of education and near work in myopia.

(Optom Vis Sci 2025;102: 289–298)

Uncorrected refractive error is the primary cause of vision impairment worldwide, affecting 157 million individuals, including both adults and children, leading to diminished educational and economic opportunities.[1] Myopia is now widely acknowledged as a major public health concern, leading to substantial visual impairment and increasing the risk of various other serious eye conditions.[2] The worldwide prevalence of myopia is estimated to be approximately 34% and is expected to increase to 50% by the year 2050.[3] It is estimated that, by 2050, myopia will be responsible for 27 to 43% of uncorrectable visual impairment in the U.S. population.[4] Other refractive errors, including hyperopia and astigmatism, are also highly prevalent (38.6 and 40.4%, respectively, in American adults) but do not carry the same sight-threatening risks as myopia.[5]

Although most cases of myopia develop during childhood and stabilize by the age of 18 years, some individuals may still exhibit myopic changes as adults.[6–8] This can involve an increase in myopia in an already myopic individual or an onset of myopia in individuals who were previously emmetropic or hyperopic. Myopia development and progression are influenced by a complex interplay of genetic, behavioral, and environmental factors.[9,10] Time spent outdoors, amount of near work, and level of education are often linked to myopia.[9,11–13] Therefore, it is expected that the prevalence, incidence, and progression of myopia would be higher in university and post-graduate students. The prevalence of myopia in the United States among young adults aged 18 to 24 and 25 to 34 years derived from the National Health and Nutrition Examination Survey was found to be substantially higher in 1999 to 2004 (38.7 and 46.3%) than in 1971 to 1972 (29.7 and 25.6%).[14] The authors speculated that the higher prevalence was due to more access to educational opportunities and more years of formal education. A report on myopia prevalence and progression by the U.S. National Research Council Committee on Vision working group concluded that 40% of individuals with low hyperopia or normal vision who entered university were likely to develop myopia by the age of 25 years, compared with less than 10% of those who did not attend university.[15]

Previous cross-sectional studies have estimated the proportion of myopia and other refractive errors in university students in the United States.[16–20] High rates of myopia prevalence were noted among law students (62.1%) and medical students (71.3%) compared with art students (36.5%), potentially due to art students having more hours of "mechanical skills" and fewer hours of reading books.[16,17] Three different studies have estimated the prevalence of myopia among optometry students in the United States, reporting 69.6% in 447 second-year students at Pacific University (1984), 65.3% in 176 first-year students at Northeastern State University (1997), and 84.4% in 64 first-year students at Nova Southeastern University (2005).[18–20] Hyperopia prevalence varied between 3.1 and 8.2%.[18–20]

[1]University of Houston College of Optometry, Houston, Texas *Lostrin@central.uh.edu

Submitted: August 27, 2024
Accepted: November 25, 2024
Funding/Support: Foundation for the National Institutes of Health (R01 EY030193; to LAO).
Conflict of Interest Disclosure: None of the authors have reported a financial conflict of interest. Other conflicts of interest include the following: LAO: Meta (research funding), Topcon (research funding), and Zeiss (consulting).
Author Contributions and Acknowledgments: Conceptualization: BL, HC, LAO; Data Curation: BL, JJ, AC; Formal Analysis: BL, LAO; Methodology: BL, HC; Resources: LAO; Writing – Original Draft: BL, HC, LAO; Writing – Review & Editing: BL, HC, LAO.

ISSN: 1538-9235/2025/1025-289298
DOI: 10.1097/OPX.0000000000002228

A recent article from the International Myopia Institute reported that the annual progression rate in myopic adults aged 18 to 25 years ranges between −0.10 and −0.20 D per year, which was higher than myopic adults aged 25 to 40 years (less than −0.10 D per year).[7] It is reported that the rate of progression tends to be higher if the study population is limited to college students, compared with studies that included a broad range of vocations.[6,7,21] A 3-year follow-up study conducted among myopic optometry students and patients in New Zealand reported a mean progression ranging from −0.18 ± 0.40 D (for early adult-onset myopes) to −0.26 ± 0.52 D (for youth-onset myopes).[21] Another study conducted in the United States at Nova Southeastern University among optometry students reported a myopic change of −0.28 D over 9 months.[19]

The most recent report of myopia prevalence and progression in optometry students and in overall young adults in United States was published in 2005.[14,19] The last two decades have witnessed an immense surge in the usage of electronic devices for near work and reading, especially among young adults, which has been speculated to contribute to onset and progression of myopia.[22] Moreover, the world underwent the pandemic of COVID-19 that led to behavioral changes and increase in near tasks due to home confinement or a lessening of outdoor activities.[23,24] It is plausible that these factors together may have impacted refractive status and progression rates of young adults. The goal of this study was to assess the prevalence of myopia and other refractive errors in optometry students in the United States. The study also aimed to explore how refractive error changed in these students over the course of their optometry education.

METHODS

This study was a retrospective chart review of electronic medical records of students enrolled in the doctor of optometry program at the University of Houston College of Optometry (UHCO) who graduated between 2013 and 2023. The study was conducted in accordance with the tenets of the Declaration of Helsinki and was approved by the institutional review board at the University of Houston.

The UHCO doctor of optometry program is a post-graduate 4-year degree. Students must have already completed an undergraduate degree. The median age of students entering optometry programs in the United States in fall 2023 was 22 years (https://optometriceducation.org/). To be included in the study, a student should have undergone at least one eye examination at the UHCO clinic during their time as optometry student. The standard comprehensive eye examination at UHCO includes visual acuity testing, ocular motility, pupils, confrontation visual fields, refraction, intraocular pressure, slit-lamp examination, and fundus evaluation. Students were excluded from the current analysis if they had any ocular disease, had undergone refractive surgery, or used any myopia control treatment. Students were included if they had nonpathological myopia-related changes in retina, such as lattice or choroidal crescents. Fig. 1 shows the study protocol and number of student records included in the analysis.

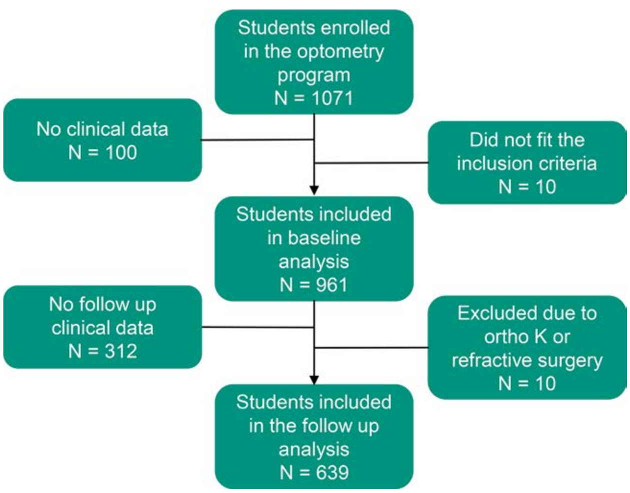

FIGURE 1. Number of student records included in each stage of the analysis.

For each student, refractive error from their first eye examination during their time as an optometry student was noted from the electronic medical record. The first eye examination was considered as the baseline visit. The majority of the records include a final refraction, as well as autorefraction or retinoscopy findings. For the purposes of the current study, final refraction was noted as the student's refraction. In cases of no final refraction in the records, autorefraction or retinoscopy was taken as refraction.

The second examination, when available in the records, was considered as the follow-up visits. The follow-up was defined as a second eye examination that occurred during optometry school and was at least 6 months (182 days) after the baseline visit. Students who developed any ocular disease, underwent refractive surgery, or commenced myopia control treatment at the follow-up visit, as per their records, were excluded from the analysis for the follow-up visit. Additionally, if the date of visit was outside their time as an optometry student (i.e., after graduation), the data were excluded in the analysis for follow-up visit.

For each eye examination, spherical equivalent refraction (SER) was calculated as sphere + ½ cylinder power for each eye. Consistent with previous studies and International Myopia Institute classification,[2,25] refraction was classified as myopic (SER ≤ −0.50 D), emmetropic (SER > −0.50 to +0.50 D), or hyperopic (SER > +0.50 D). Myopia was further grouped into low myopia (SER ≤ −0.50 to > −3.00 D), moderate myopia (SER of −3.00 to > −6.00 D), and high myopia (SER ≤ −6.00 D). Astigmatism was defined as cylindrical power > 0.50 D and further grouped into low astigmatism (cylindrical power > 0.50 to < 3.00 D) and high astigmatism (cylindrical power ≥ 3.00 D). Anisometropia was defined as an SER difference of ≥ 1.00 D between the two eyes.[26,27]

Prevalence and 95% confidence intervals (CIs) were calculated for each refractive group for baseline and follow-up visits. Absolute change in SER was calculated by subtracting baseline SER from the follow-up SER. Annualized change was calculated by dividing absolute change in SER by the follow-up duration in years between visits. Means and standard deviations were calculated for continuous variables and proportions for categorical variables unless stated otherwise. Students were grouped into five age groups for comparison: 20 to 21, 22 to 23, 24 to 25, 26 to 30, and older than 30 years.

Data were examined for normality with the Kolmogorov-Smirnov test, and nonparametric tests were used, where required. The Wilcoxon test was used to compare SER between the two eyes and between visits. SER was compared between genders using the Mann-Whitney *U* test and among classes (by graduation year) and age groups using the Kruskal-Wallis *H* test. The χ^2 test was used to compare proportions between groups. Spearman correlation was used to study associations. The level of significance was set as less than 0.05.

RESULTS

Baseline eye examinations

A total of 1071 students enrolled in UHCO from 2009 to 2019, having graduation dates from 2013 to 2023, referred to henceforth as classes of 2013 to 2023. Table 1 shows the number of students enrolled each year, indicated by their graduation year. Of 1071 students, 971 had at least one examination in the UHCO optometry clinic electronic medical records, representing 91% of the student population. Ten students were excluded from the analysis due to amblyopia, refractive surgery, trauma, or ocular pathology (Table 1). Thus, 961 students were included in baseline data analysis. Myopia-related retinal changes were noted in the records for 10 students, including retinal holes (n = 4), lattice degeneration (n = 2), choroidal crescent (n = 2), horseshoe tear (n = 1), and tigroid fundus (n = 1); however, nonpathological myopic changes may not have been included in the medical records. These students were included in further analysis.

Among the 961 students, 590 (61.4%) had their baseline eye examination during their first year of the optometry program, 331 (34.4%) in the second year, 38 (4%) in the third year, and 2 (0.02%) in the fourth year. The mean age for the baseline eye examination was 24 ± 2.9 years (range, 20 to 57 years), with 634 females and 327 males. Females were significantly younger than males (23.6 ± 2.3 and 24.7 ± 3.7 years, respectively; p<0.001). When compared by class, gender distribution was similar (p=0.36).

Table 2 summarizes refractive error (sphere, cylinder, and SER) in right and left eyes, class-wise and total, for all baseline examinations. Refractive error was determined from the electronic record from final refraction for 936 students, autorefraction for 23 students, and retinoscopy for 2 students. Mean spherical component and SER for right and left eyes were not significantly different (p=0.72 and p=0.39, respectively). The cylindrical refraction for right eyes was significantly lower than for left eyes by approximately 0.04 D (−0.67 ± 0.78 and −0.71 ± 0.83 D, respectively, p=0.01). Given that SER for right and left eyes was statistically similar, data from the right eye of each student were used for all further analyses.

At the baseline visit, the spherical component and SER for right eyes were significantly more negative (i.e., more myopic) for females (−2.96 ± 2.77 and −3.29 ± 2.85 D) than males (−2.51 ± 2.76 and −2.84 ± 2.84 D, p=0.02 for both). The cylindrical component was statistically similar between males (−0.67 ± 0.77 D) and females (−0.66 ± 0.79 D, p=0.76). When compared across classes by graduation year, there was no significant difference in SER (p=0.24). However, the SER was significantly different between the five age groups (p<0.001), with the youngest group showing more negative refraction compared with the older age groups (20 to 21 years: −4.29 ± 3.19 D [n = 48]; 23 to 24 years: −3.40 ± 2.80 D [n = 476]; 24 to 25 years: −2.74 ± 2.84 D [n = 283]; 26 to 30 years: −2.88 ± 2.71 D [d = 124]; older than 30 years: −1.90 ± 2.78 D [n = 30]).

Fig. 2A shows the frequency distribution of SER for right eyes at the baseline visit for all students, and Table 3 shows the class-wise and total prevalence of refractive errors. No significant difference was noted between classes for prevalence of refractive errors (p=0.76). Overall, myopia prevalence was 80.7% (95% CI, 78.3 to 83.2%; n = 776), emmetropia prevalence was 14.9% (95% CI, 12.6 to 17.1%; n = 143), and hyperopia prevalence was 4.4% (95% CI, 3.1 to 5.7%; n = 42). Mean SER was −4.00 ± 2.41 D for myopes, +0.06 ± 0.27 D for emmetropes, and +1.98 ± 1.70 D for hyperopes. Prevalences were not significantly different between males and females (p=0.29). The low myopia prevalence was 30.8% (95% CI, 27.9 to 33.7%; n = 296), moderate myopia prevalence was 33.8% (95% CI, 30.8 to 36.8%; n = 325), and high myopia prevalence was 16.1% (95% CI, 13.8 to 18.5%; *n* = 155). Astigmatism prevalence was 38.4% (95% CI, 35.3 to 41.5%; n = 369), with low astigmatism prevalence of 35.7% (95% CI, 32.7 to 38.7%; n = 343) and high astigmatism prevalence of 2.7% (95% CI, 1.7 to 3.7%; n = 26). The prevalence of anisometropia was 16.1% (95% CI, 13.8 to 18.5%; n = 155).

Follow-up examinations

Of the 961 students included in the baseline analysis, 639 (66.5%) visited the clinic for a follow-up examination. For these 639 students, baseline mean SER in the right eyes was −3.59 ± 2.76 D. Among them, 566 (88.6% [95% CI, 86.1 to 91.0%]) were myopes (118 high myopes, 249 moderate myopes, and 199 low myopes), 51 (8.0% [95% CI, 5.9 to 10.1%]) were emmetropes, and 22 (3.4% [95% CI, 2.0 to 4.9%]) were hyperopes. Mean SERs in myopes, emmetropes, and hyperopes were −4.15 ± 2.37, +0.06 ± 0.28, and +2.31 ± 1.86 D, respectively.

TABLE 1. Student demographics for students enrolled at the University of Houston College of Optometry in graduating classes of 2013–2023

Graduating year	No. of students enrolled	No. of students with at least one exam	No. of students excluded	No. of students included in the analysis (F:M)	Age (y), mean ± SD (range)
2013	107	93	1	92 (53:39)	24.3 ± 4.2 (20–57)
2014	93	78	2	76 (50:26)	23.7 ± 2.3 (21–32)
2015	94	91	0	91 (54:37)	23.9 ± 1.9 (21–33)
2016	101	89	1	88 (63:25)	24.0 ± 2.7 (21–37)
2017	87	78	0	78 (50:28)	23.9 ± 2.5 (20–37)
2018	102	88	2	86 (59:27)	23.9 ± 2.5 (20–35)
2019	103	99	0	99 (62:37)	23.9 ± 2.2 (20–30)
2020	97	85	1	84 (64:20)	24.6 ± 3.2 (21–45)
2021	99	94	1	93 (61:32)	23.9 ± 2.0 (20–32)
2022	95	92	2	90 (61:29)	23.9 ± 3.5 (21–45)
2023	93	84	0	84 (57:27)	23.5 ± 4.0 (20–51)
Total	1071	971	10	961 (634:327)	24.0 ± 2.9 (20–57)

F = female; M = male; SD = standard deviation.

TABLE 2. Mean ± standard deviation (range) of the sphere (D) and cylinder (D) components and SER of right and left eyes for baseline examinations by graduation year

	Right eye			Left eye		
Graduating year (n)	**Sphere (D)**	**Cylinder (D)**	**SER (D)**	**Sphere (D)**	**Cylinder (D)**	**SER (D)**
2013 (92)	−3.53 ± 2.90 (−11.75 to +5.25)	−0.64 ± 0.63 (−3.50 to 0.00)	−3.85 ± 2.99 (−13.50 to −4.50)	−3.42 ± 2.98 (−13.50 to +5.00)	−0.67 ± 0.71 (−4.25 to 0.00)	−3.76 ± 3.07 (−14.88 to +4.38)
2014 (76)	−3.09 ± 2.61 (−10.50 to +4.75)	−0.65 ± 0.90 (−4.75 to 0.00)	−3.42 ± 2.60 (−10.75 to −3.13)	−3.12 ± 2.68 (−11.50 to +5.50)	−0.78 ± 1.02 (−5.25 to 0.00)	−3.51 ± 2.66 (−11.75 to +3.75)
2015 (91)	−3.02 ± 2.75 (−11.50 to +5.25)	−0.61 ± 0.71 (−3.0 to 0)	−3.33 ± 2.84 (−11.88 to +4.75)	−2.98 ± 2.72 (−11.50 to +5.50)	−0.65 ± 0.66 (−2.75 to 0.00)	−3.30 ± 2.80 (−12.13 to +5.00)
2016 (88)	−2.89 ± 2.77 (−11.75 to +5.00)	−0.60 ± 0.73 (−3.00 to 0.00)	−3.19 ± 2.85 (−12.13 to +4.75)	−2.94 ± 2.97 (−10.75 to +5.00)	−0.58 ± 0.72 (−3.50 to 0.00)	−3.23 ± 2.99 (−10.75 to +4.75)
2017 (78)	−2.82 ± 2.71 (−10.75 to +1.25)	−0.69 ± 0.82 (−3.75 to 0.00)	−3.17 ± 2.85 (−11.50 to +1.00)	−2.84 ± 2.72 (−10.50 to +1.50)	−0.77 ± 0.82 (−3.25 to 0.00)	−3.22 ± 2.82 (−11.13 to +1.00)
2018 (86)	−2.31 ± 2.43 (−8.25 to +3.75)	−0.60 ± 0.69 (−3.50 to 0.00)	−2.61 ± 2.50 (−9.13 to 3.38)	−2.30 ± 2.61 (−9.00 to +3.00)	−0.62 ± 0.73 (−3.25 to 0.00)	−2.61 ± 2.71 (−9.88 to +2.88)
2019 (99)	−2.87 ± 2.97 (−11.00 to 7.50)	−0.61 ± 0.73 (−3.75 to 0.00)	−3.17 ± 3.07 (−11.63–7.38)	−2.88 ± 2.94 (−10.25 to +7.25)	−0.61 ± 0.81 (−5.00 to 0.00)	−3.18 ± 3.01 (−11.25 to +7.25)
2020 (84)	−2.85 ± 3.02 (−12.00 to +4.50)	−0.77 ± 0.97 (−4.75 to 0.00)	−3.24 ± 3.09 (−12.38 to +3.50)	−2.80 ± 3.11 (−12.25 to +6.00)	−0.82 ± 1.08 (−5.50 to 0.00)	−3.20 ± 3.16 (−12.25 to +5.00)
2021 (93)	−2.40 ± 2.50 (−7.75 to +1.50)	−0.70 ± 0.75 (−3.50 to 0.00)	−2.75 ± 2.56 (−8.50 to +1.38)	−2.46 ± 2.56 (−9.50 to +1.75)	−0.72 ± 0.80 (−3.00 to 0.00)	−2.83 ± 2.63 (−10.88 to +1.38)
2022 (90)	−2.49 ± 2.83 (−9.75 to +4.25)	−0.72 ± 0.77 (−3.5 to 0.00)	−2.85 ± 2.91 (−10.25 to +4.25)	−2.40 ± 2.85 (−10.25 to +4.00)	−0.78 ± 0.72 (−3.00 to 0.00)	−2.79 ± 2.90 (−11.13 to +2.50)
2023 (84)	−2.60 ± 2.83 (−10.75 to +7.00)	−0.74 ± 0.90 (−3.75 to 0.00)	−2.97 ± 2.94 (−12.00 to 6.38)	−2.55 ± 2.78 (−10.00 to +7.25)	−0.82 ± 1.00 (−4.50 to 0.00)	−2.96 ± 2.93 (−12.00 to +6.88)
Total (961)	−2.81 ± 2.77 (−12.00 to 7.50)	−0.67 ± 0.78 (−4.75 to 0.00)	−3.14 ± 2.85 (−13.50 to + 7.38)	−2.79 ± 2.82 (−13.50 to + 7.25)	−0.71 ± 0.83 (−5.50 to 0.00)	−3.14 ± 2.89 (−14.88 to + 7.25)

SER = spherical equivalent refraction.

Mean duration between baseline and follow-up visit was 1.60 ± 0.61 years (range, 0.53 to 3.43 years). The follow-up duration was not significantly different between genders (p=0.84) or among age groups (p=0.59). The absolute difference in SER between the two visits was −0.05 ± 0.38 D (range, −1.25 to +1.63 D), which was significantly more myopic (p=0.001). The number of students who were classified as a different refractive error group at the follow-up examination is shown in Table 4.

Myopes showed a significant myopic change from baseline to the follow-up of −0.06 ± 0.38 D (p<0.001). The low and moderate myopes showed significant changes (p=0.002 and p=0.007) of −0.08 ± 0.36 D (follow-up duration, 1.68 ± 0.61 years) and −0.06 ± 0.35 D (follow-up duration, 1.55 ± 0.61 years), respectively. However, high myopes did not exhibit a significant change (−0.05 ± 0.48 D; follow-up duration, 1.60 ± 0.63 years; p=0.34).

Of the 199 low myopes at baseline, 175 were still classified as low myopes at the follow-up examination. Seven became emmetropes, with a mean positive change of +0.32 ± 0.10 in SER (follow-up duration, 1.56 ± 0.70 years; p=0.02), and 17 became moderate myopes, with a mean negative change of −0.54 ± 0.26 D (follow-up duration, 2.10 ± 0.61 years; p<0.001).

Of the 249 moderate myopes at baseline, 231 were still classified as moderate myopes at the follow-up examination, with a significant negative change of −0.05 ± 0.33 D (follow-up duration, 1.54 ± 0.62 years; p=0.03). Twelve became high myopes, with a negative change of −0.47 ± 0.25 D (follow-up duration, 1.64 ± 0.39 years; p=0.002), and six became low myopes, with a positive change of +0.27 ± 0.05 (follow-up duration, 1.38 ± 0.41 years; p=0.02).

Of the 118 high myopes at baseline, 113 were still classified as high myopes at the follow-up examination, with no significant change in refractive error (p=0.12). However, five became moderate myopes at the follow-up examination, with a positive change of +0.58 ± 0.34 D (follow-up duration, 1.32 ± 0.45 years; p=0.04).

Spherical equivalent refraction in emmetropes did not significantly change (+0.03 ± 0.37 D, p=0.82) over a follow-up duration of 1.53 ± 0.55 years. Of the 51 emmetropes at baseline, 33 were still classified as emmetropes at the follow-up examination. Eight became low myopes, with a negative change of −0.33 ± 0.13 D (follow-up duration, 1.46 ± 0.62 years; p=0.01), and 10 became hyperopes, with a positive change of +0.53 ± 0.28 D (follow-up duration, 1.33 ± 0.48 years; p=0.005).

Spherical equivalent refraction in hyperopes did not change significantly (+0.14 ± 0.40 D; follow-up duration, 1.56 ± 0.56 years; p=0.13). Of the 22 hyperopes at baseline, 21 remained hyperopes at the follow-up visit, with no significant change in refractive error (p=0.05), and one student became an emmetrope, with a negative change of −0.50 D over 2.57 years.

Fig. 3 shows changes in SER with follow-up duration and with age at baseline. A more negative absolute change in SER was observed with increased follow-up duration (ρ = −0.12, p=0.003) and with younger age (ρ = 0.09, p=0.02), which was mostly driven by the myopic students (ρ = −0.13, p=0.002 for follow-up duration and ρ = −0.09, p=0.04 for age). The association between absolute change in SER and follow-up duration was more negative and significant for the younger age groups (20 to 21 years [n = 35]: ρ = −0.34, p=0.04; 23 to 24 years [n = 362]: ρ = −0.14, p=0.01) compared with the older age groups (24 to 25 years

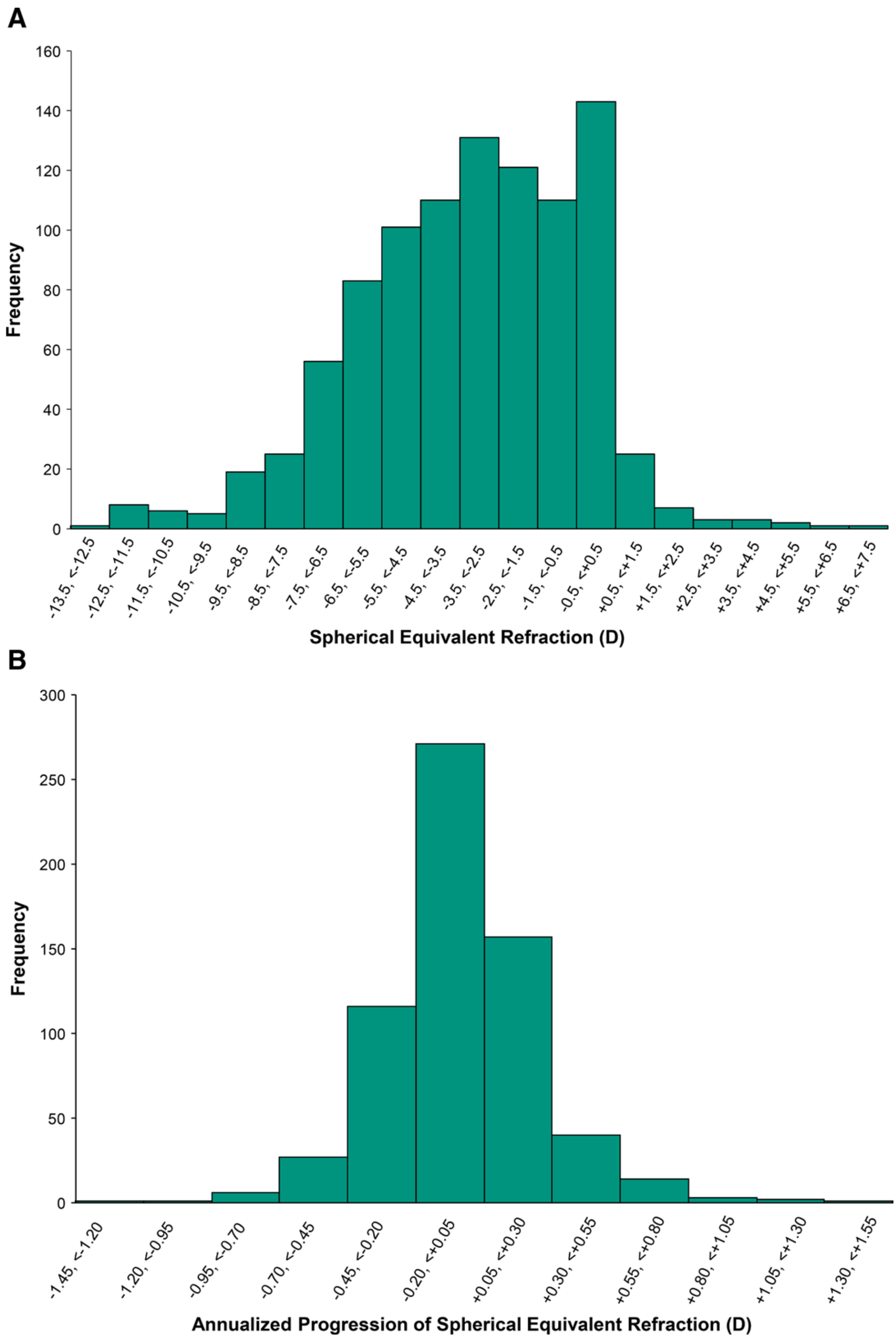

FIGURE 2. (A) Spherical equivalent refraction (in diopters) distribution for all students at the baseline examinations (n=961). (B) Annualized progression of spherical equivalent refraction (in diopters) distribution for students who underwent baseline and follow-up examination (n=639).

TABLE 3. Class-wise and total prevalence of refractive errors (n (%) [95% confidence interval]) based on spherical equivalent refraction from baseline examinations (n=961)

Graduating year (n)	Emmetropia	Hyperopia	Myopia	Low myopia	Moderate myopia	High myopia	Astigmatism	Anisometropia
2013 (92)	8 (8.7%) [2.9–14.5]	4 (4.3%) [0.2–8.5]	80 (87.0%) [80.1–93.8]	26 (28.3%) [19.1–37.5]	34 (37.0%) [27.1–46.8]	20 (21.7%) [13.3–30.2]	41 (44.6%) [34.4–54.7]	16 (17.4%) [9.6–22.4]
2014 (76)	6 (7.9%) [1.8–14.0]	3 (3.9%) [−0.4 to 8.3]	67 (88.2%) [80.9–95.4]	27 (35.5%) [24.8–46.3]	27 (35.5%) [24.8–46.3]	13 (17.1%) [8.6–25.6]	25 (32.9%) [22.3–43.5]	11 (14.5%) [6.6–22.4]
2015 (91)	12 (13.2%) [6.2–20.1]	3 (3.3%) [−0.4 to 7.0]	76 (83.5%) [75.9–91.1]	26 (28.6%) [19.3–37.9]	35 (38.5%) [28.5–48.5]	15 (16.5%) [8.9–24.1]	31 (34.1%) [24.3–43.8]	15 (16.5%) [8.9–24.1]
2016 (88)	18 (20.5%) [12.0–28.9]	4 (4.5%) [0.2–8.9]	66 (75.0%) [66.0–84.0]	17 (19.3%) [11.1–27.6]	36 (40.9%) [30.6–51.2]	13 (14.8%) [7.4–22.2]	32 (36.4%) [26.3–46.4]	18 (20.5%) [12–28.9]
2017 (78)	10 (12.8%) [5.4–20.2]	3 (3.8%) [−0.4 to 8.1]	65 (83.3%) [75.1–91.6]	31 (39.7%) [28.9–50.6]	20 (25.6%) [16–35.3]	14 (17.9%) [9.4–26.5]	26 (33.3%) [22.9–43.8]	9 (11.5%) [4.4–18.6]
2018 (86)	17 (19.8%) [11.4–28.2]	3 (3.5%) [−0.4 to 7.4]	66 (76.7%) [67.8–85.7]	30 (34.9%) [24.8–45.0]	26 (30.2%) [20.5–39.9]	10 (11.6%) [4.9–18.4]	30 (34.9%) [24.8–45.0]	12 (14.0%) [6.6–21.3]
2019 (99)	12 (12.1%) [5.7–18.6]	5 (5.1%) [0.7–9.4]	82 (82.8%) [75.4–90.3]	31 (31.3%) [22.2–40.4]	35 (35.4%) [25.9–44.8]	16 (16.2%) [8.9–23.4]	37 (37.4%) [27.8–46.9]	20 (20.2%) [12.3–28.1]
2020 (84)	9 (10.7%) [4.1–17.3]	5 (6.0%) [0.9–11.0]	70 (83.3%) [75.4–91.3]	29 (34.5%) [24.4–44.7]	25 (29.8%) [20.0–39.5]	16 (19.0%) [10.7–27.4]	31 (36.9%) [26.6–47.2]	12 (14.3%) [6.8–21.8]
2021 (93)	20 (21.5%) [13.2–29.9]	4 (4.3%) [0.2–8.4]	69 (74.2%) [65.3–83.1]	28 (30.1%) [20.8–39.4]	26 (28.0%) [18.8–37.1]	15 (16.1%) [8.7–23.6]	43 (46.2%) [36.1–56.4]	7 (7.5%) [2.2–12.9]
2022 (90)	18 (20.0%) [11.7–28.3]	4 (4.4%) [0.2–8.7]	68 (75.6%) [66.7–84.4]	26 (28.9%) [19.5–38.3]	30 (33.3%) [23.6–43.1]	12 (13.3%) [6.3–20.4]	40 (44.4%) [34.2–54.7]	17 (18.9%) [10.8–27.0]
2023 (84)	13 (15.5%) [8.7–24.6]	4 (4.8%) [0.2–9.3]	66 (78.6%) [69.8–87.3]	25 (29.8%) [18.9–38.2]	31 (36.9%) [26.6–47.2]	11 (13.1%) [5.9–20.3]	33 (39.3%) [28.8–49.7]	18 (21.4%) [12.7–20.2]
Total (961)	143 (14.9%) [12.6–17.1]	42 (4.4%) [3.1–5.7%]	776 (80.7%) [78.3–83.2%]	296 (30.8%) [27.9–33.7%]	325 (33.8%) [30.8–36.8%]	155 (16.1%) [13.8–18.5]	369 (38.4%) [35.3–41.5]	155 (16.1%) [13.8–18.5]

[n=162]: ρ=−0.09, p=0.28; 26 to 30 years [n=68]: ρ=−0.05, p=0.71; older than 30 years [n=12]: ρ=−0.39, p=0.21).

The mean annualized change in SER between baseline and follow-up visit for 639 students was −0.02±0.29 D (range, −1.45 to +1.40 D), which was significantly different from zero (p=0.007). The frequency distribution of the annualized change in SER is shown in Fig. 2B. The mean annualized changes in SER among myopes, emmetropes, and hyperopes were −0.03±0.29 D (range, −1.45 to +1.40 D), −0.02±0.31 D (range, −0.68 to +0.76 D), and +0.09±0.24 D (range, −0.33 to +0.55 D), respectively. Only myopes showed an annualized negative change in SER that was significantly different from zero (p=0.001).

Based on the annualized change in SER, a negative change of −0.25 D or more was noted in 128 students (20.0%; 118 myopes, 2 hyperopes, and 8 emmetropes), of which 35 students (5.5%) showed an annual progression of −0.50 D or more. A hyperopic change of more than +0.50 D occurred for 25 students (3.9%).

Among age groups, the annualized change in SER tended to be more negative for the younger groups (20 to 21 years: −0.02±0.31 D; 23 to 24 years: −0.04±0.29 D; 24 to 25 years:

TABLE 4. Number of students in each refractive error group at baseline and follow-up (n=639)

Refractive group at baseline (n)	Refractive group at the follow-up (n)	Follow-up duration (y), mean±SD	SER (D) difference between visits, mean±SD	Wilcoxon test, p value
Hyperopia (22)	Hyperopia (21)	1.52±0.52	+0.17±0.38	0.05
	Emmetropia (1)	2.57	−0.50	—
Emmetropia (51)	Hyperopia (10)	1.33±0.48	+0.53±0.28	0.01*
	Emmetropia (33)	1.62±0.55	−0.04±0.28	0.44
	Low myopia (8)	1.46±0.62	−0.33±0.13	0.01*
Low myopia (199)	Emmetropia (7)	1.56±0.7	+0.32±0.1	0.02*
	Low myopia (175)	1.65±0.59	−0.05±0.33	0.03*
	Moderate myopia (17)	2.1±0.61	−0.54±0.26	<0.001*
Moderate myopia (249)	Low myopia (6)	1.38±0.41	+0.27±0.05	0.02*
	Moderate myopia (231)	1.54±0.62	−0.05±0.34	0.03*
	High myopia (12)	1.64±0.39	−0.47±0.25	<0.001*
High myopia (118)	Moderate myopia (5)	1.32±0.45	+0.58±0.34	0.04*
	High myopia (113)	1.61±0.64	−0.08±0.47	0.12

*Significance at <0.05. SD=standard deviation; SER=spherical equivalent refraction.

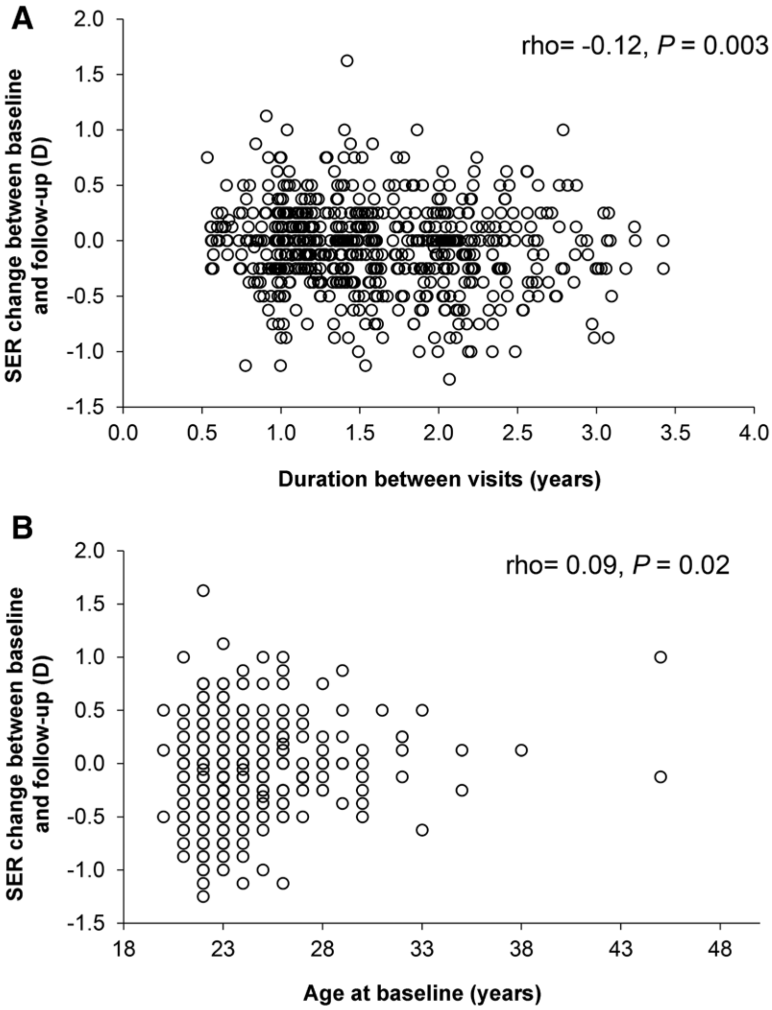

FIGURE 3. Change in spherical equivalent refraction (SER) with (A) duration between visits and (B) age at the baseline visit for students who had a follow-up visit (n=639).

−0.01±0.29 D; 26 to 30 years: +0.04±0.29 D; older than 30 years: +0.04±0.33 D); however, these differences failed to reach significance (p=0.05). No significant difference was noted in the annualized change in SER between genders (p=0.76) or graduation year (p=0.33).

DISCUSSION

The present study quantified the prevalence and progression of myopia and other refractive conditions among U.S. optometry graduates between 2013 and 2023. The results show that the prevalence of myopia was 80.7%, emmetropia was 14.9%, and hyperopia was 4.4%. Additionally, 38.4% had astigmatism, and 16.1% had anisometropia. The prevalences of low, moderate, and high myopia were 30.8%, 33.8%, and 16.1%, respectively. Students demonstrated a small but significant myopic change in refraction of −0.05 D over an average follow-up period of 1.60 years. Myopia onset was observed in 15.7% of emmetropes at baseline.

Previous studies have reported high rates of myopia prevalence among first- and second-year optometry students in the United States, United Kingdom, and Israel, ranging between 65.3 and 84.4%.[18–20,25,28] The extensive duration of the education may contribute to the high prevalence of myopia.[18,19,28] In addition, many myopic students might be drawn to pursue optometry due to their ocular condition and the influence of their optometrists. Myopia prevalence found here, 80.7%, encompassed students who were primarily in the first year and second year of the optometry program. This result is similar to the prevalence reported by Jiang et al.,[19] who found 84.4% of myopia prevalence among 64 first-year optometry students in the United States, although a slightly lower prevalence was found in other two studies in the United States (69.6 and 65.3%),[18,20] one in the United Kingdom (55.6%),[28] and one in Israel (68.3%).[25] Given that the current global prevalence of myopia is increasing, these differences in prevalence over time may reflect a change in characteristics of cohorts enrolling in optometry education.

Higher level of education and more years of formal education are often linked to myopia, possibly explaining the more myopic mean refraction in the present study.[29,30] Upon enrolling in optometry schools in the United States, students have completed 3 to 4 years of university, with some having other careers before optometry school. Therefore, the average age of U.S. optometry students and number of years of education are typically higher than in the United Kingdom and Israel, where students enter after high school. Mean SER in the current study was −3.14 D, which is more myopic than previous studies conducted in optometry students in the United States, reporting SERs ranging between −1.75 and −2.25 D.[18–20,25] These discrepancies could be due to specific population characteristics, such as ethnicity, or number of years of formal education before entering into optometry school. A study conducted in the United Kingdom that included first-year university students from a range of disciplines, including optometry, pharmacy, biology, engineering, and business studies, reported a less myopic refraction of −1.23 D, with only 52.7% of them being myopic.[31] Given the increased usage of electronic devices for near work and impact of COVID-19, it may be expected that average refraction among optometry students is myopic and is progressing toward a high magnitude, when compared with the studies previously conducted in the United States among optometry students.[19]

A meta-analysis of hyperopia, including 46 articles, reported a prevalence of hyperopia of 37.2% in American adults.[5] In the present study, only 4.4% of optometry students were hyperopic. Similarly, among other studies in optometry students, the prevalence of hyperopia ranged from 3.1 to 8.2%.[18–20] The prevalence of astigmatism was 38.4% in the present study, similar to the reported global prevalence of astigmatism in adults (40%), but lower than that in university students in Israel (48.9%). Differences in astigmatism prevalence may be due to palpebral fissure shape and ethnic and racial differences.[5] Anisometropia was present in 16.1% of the optometry students, similar to a study conducted among university students in China (20.9%).[32]

Among students who were initially emmetropic, 15.7% (8 of 51) developed myopia at the follow-up, whereas 5.1% (29 of 566) who were already myopic at baseline were reclassified and experienced further progression. This is substantially lower than a study in Norwegian university students with a mean age of 21 years, which found that 59% of emmetropic students developed myopia, and 73% of the myopic students progressed over a 3-year follow-up duration.[33] Although previous studies among university students found a decrease in prevalence of hyperopia over 3 years,[33,34] in the present study, the number of hyperopes increased from 22 to 31 at the follow-up visit. Interestingly, 28 of 639 students with a follow-up examination demonstrated a significant positive change in refraction. We speculate that this increase in hyperopia prevalence and small positive changes in refraction may be due to variability in each student's level of tonic accommodation or the variability in refraction measures between clinicians at the follow-up visit.

A recent study reported an annualized change of −0.09 D among myopic adults aged 18 to 30 years who presented at a university-based clinic in Australia.[8] Another study reported an annualized change of −0.04 D in 20-year-old adults from a population-based study in Australia.[6] The present study found a significant annualized change in SER of −0.02 D in 639 optometry students, which was mostly driven significant by myopes, who demonstrated an annualized change of −0.03 D. These changes were smaller than previous studies that reported refraction changes in optometry students, which ranged between −0.06 and −0.37 D per year.[19,21] Similarly, studies among university students attending air force academy, engineering, science, and medicine progressed faster, with an annualized change between −0.10 and −0.17 D.[33–38] The reasons for these variations in the annualized progression could be possibly explained by inclusion of relatively younger students than the present study, as well as varying ethnicities and geographical locations. Studies have suggested that myopia progression is significantly associated with age, with younger population depicting a larger negative change per year.[8,34,39] The present study did not find an influence of younger age group on annualized progression, possibly due to a smaller sample size in that group. However, only the younger age group (≤24 years) demonstrated larger negative changes with longer follow-up duration. COMET (Correction of Myopia Evaluation Trial), which used Gompertz curve–based estimates to predict stabilization, reported that 90% of their myopic cohort would stabilize by age 21 years and 96% by age 24 years.[40] Our results in a way concur with these estimates, finding that myopic progression gradually halts and refraction stabilizes by the age of 24 years.

In our cohort, 20% experienced an annualized negative change in refraction of −0.25 D or greater, with 5.5% of them showing a negative change of −0.50 D or more. These findings were similar to a retrospective study conducted among myopic adults attending a university-based research clinic in Australia, demonstrating 139 eyes (15.1%) with a progression of −0.25 D or more per year, of which 31 eyes (3.4%) progressed by −0.50 D per year.[8]

Studies have shown that prevalence of myopia is increasing over time.[5,14,41] For example, Vitale et al.[14] found that prevalence of myopia in the United States was substantially higher in 1999 to 2004 compared with 30 years earlier. Therefore, our data were stratified by year of graduation. It was anticipated that graduating classes of 2021, 2022, and 2023, who underwent education through COVID-19, may have had a higher prevalence of myopia or greater myopic changes over time. However, over the 10 years that data were included for this study, there was not a significant increase in myopia prevalence or negative change in refraction with time. To notice a substantial change in the myopia prevalence, it is likely necessary to explore data over a larger period of time, such as the 30-year span done by Vitale et al.[14] A generation is considered to be a 20- to 30-year time period.[42] Studies suggest that prevalence of myopia increases over generations, owing to changes in environmental and behavioral factors such as education and near work.[10,43–45] The gene pool changes minimally between generations, whereas changes in the environment are more rapid, hence supporting the increase in prevalence over generations.[9,46] Therefore, it is possible that significant changes in optometry student myopia prevalence may emerge within 10 to 20 years from the current analysis.

Female gender has been commonly reported to be associated with myopia.[25,47,48] The present study found that females were more myopic by approximately −0.50 D than males, similar to a previous study conducted among optometry and nonoptometry students. However, females were younger by a year than males in the current study, which may have contributed to differences in refraction. Although females were more myopic in the current study, the prevalence of myopia was similar between genders, contrary to a previous study in which the prevalence of myopia was higher in females than in males.[25] It could be that being myopic encouraged both genders equally to pursue optometry, thereby resulting in similar prevalences across genders. Future studies aimed at qualitatively exploring motivations behind myopic students joining optometry across genders would be informative.

The prevalence of myopic maculopathy has a nonlinear relationship with severity of myopia in individuals older than 49 years.[49] Data from the Blue Mountains Eye Study showed that myopes less than −5 D had a myopic retinopathy prevalence of 0.42% compared with 25.3% for myopes greater than −5 D, representing a 60-fold (5924%) increase in risk in higher myopes. Additionally, beyond −9 D, the prevalence was greater than 50%.[50] In the present study, 24.2% of the student population had myopia greater than −5 D, and 3% had myopia greater than −9

D. These individuals will be more prone to myopia-related complications, which may contribute to reduced quality of life and a possible rise in burden related to lost productivity in the future.[51]

The current study does present some limitations. Our study sample was limited to optometry students and is not a representative of the young adult population; hence, the results cannot be generalized. Optometry students were selected for the study because we were interested in studying a population with extensive near-work demands, which may significantly contribute to myopia development and progression.[9] Due to the retrospective study design, we were limited to the information available in the medical records. Therefore, we were not able to include axial length as a biomarker for myopia progression in our analysis, given that axial length measurement is not a part of the standard eye examination protocol. For the same reason, we were unable to obtain information on the age at onset of myopia, which could have provided further insights on myopia progression.[7] Considering that the refraction data span over a decade from the clinic, our results may be influenced by the use of various autorefraction instruments and the involvement of various clinicians in performing refraction over this period.

Another limitation of the study was regarding the uncertainty about whether cycloplegic refraction was performed before finalizing the prescription. A previous study suggested that differences between cycloplegic and noncycloplegic refraction in adults aged 20 to 26 years are on the order of +0.02 D for myopes and +0.08 D for hyperopes.[52] Therefore, cycloplegia is expected to have minimal influence on our findings. Another concern was that the interval between visits was highly variable (6 months to 3.5 years) across students. To address this issue, the differences between the visits were annualized, which still may not be sufficient to account for the nonlinear nature of myopia progression in adults. Greater changes in refraction may have emerged if all students were followed up from their first year in the optometry program to the final year. Only 66% of the students presented for a follow-up examination. Of 143 emmetropes at baseline, only 51 presented for a follow-up examination. It should be noted that emmetropes may be less likely to have regular examinations; hence, low degrees of myopia may go undiagnosed. It is also possible that students with ocular complaints were likely to report more frequently to the clinic. Due to the retrospective design of this clinic-based study, it is challenging to accurately determine the number of individuals who visited for a specific ocular complaint versus those attending for a routine eye examination. Given this, the results may not be representative of the full student population. We also acknowledge the occurrence of COVID-19 for a portion of the population. To overcome these limitations, future studies should be longitudinal and prospective in nature and designed to include additional risk factors and biomarkers of myopia progression, such as time of myopia onset, axial length, and potential behavioral contributions.

In conclusion, the present study demonstrates a high prevalence of myopia among optometry graduates from 2013 to 2023. Students demonstrated a small, but significant, myopic change in refraction. The changes were greater with increased follow-up duration and younger age. These findings may implicate a role of education and near work in myopia.

REFERENCES

1. Vision Loss Expert Group of the Global Burden of Disease Study; GBD 2019 Blindness and Vision Impairment Collaborators. Global estimates on the number of people blind or visually impaired by uncorrected refractive error: A meta-analysis from 2000 to 2020. *Eye (Lond)* 2024;38:2083–101.
2. Flitcroft DI, He M, Jonas JB, et al. IMI—Defining and classifying myopia: A proposed set of standards for clinical and epidemiologic studies. *Invest Ophthalmol Vis Sci* 2019;60:M20–30.
3. Holden BA, Fricke TR, Wilson DA, et al. Global prevalence of myopia and high myopia and temporal trends from 2000 through 2050. *Ophthalmology* 2016;123:1036–42.
4. Bullimore MA, Brennan NA. The underestimated role of myopia in uncorrectable visual impairment in the United States. *Sci Rep* 2023;13:15283.
5. Hashemi H, Fotouhi A, Yekta A, et al. Global and regional estimates of prevalence of refractive errors: Systematic review and meta-analysis. *J Curr Ophthalmol* 2018;30:3–22.
6. Lee SS, Lingham G, Sanfilippo PG, et al. Incidence and progression of myopia in early adulthood. *JAMA Ophthalmol* 2022;140:162–9.
7. Bullimore MA, Lee SS, Schmid KL, et al. IMI-onset and progression of myopia in young adults. *Invest Ophthalmol Vis Sci* 2023;64:2.
8. Khan HA, Naduvilath T, Tahhan N, Sankaridurg PR. Myopia progression in adults: A retrospective analysis. *Optom Vis Sci* 2023;100:537–42.
9. Morgan IG, Wu PC, Ostrin LA, et al. IMI risk factors for myopia. *Invest Ophthalmol Vis Sci* 2021;62:3.
10. Tedja MS, Haarman AEG, Meester-Smoor MA, et al. IMI—Myopia genetics report. *Invest Ophthalmol Vis Sci* 2019;60:M89–105.
11. Read SA, Collins MJ, Vincent SJ. Light exposure and physical activity in myopic and emmetropic children. *Optom Vis Sci* 2014;91:330–41.
12. 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.
13. Han SB, Jang J, Yang HK, et al. Prevalence and risk factors of myopia in adult Korean population: Korea National Health And Nutrition Examination Survey 2013–2014 (KNHANES VI). *PLoS One* 2019;14:e0211204.
14. Vitale S, Sperduto RD, Ferris FL3rd. Increased prevalence of myopia in the United States between 1971–1972 and 1999–2004. *Arch Ophthalmol* 2009;127:1632–9.
15. National Research Council (US) Committee on Vision. *Myopia: Prevalence and Progression*. Washington, DC: National Academies Press; 1989.
16. Loman J, Quinn GE, Kamoun L, et al. Darkness and near work: Myopia and its progression in third-year law students. *Ophthalmology* 2002;109:1032–8.
17. Shulkin DJ, Bari MM. Deteriorating vision—An occupational risk for the medical student. *Arch Ophthalmol* 1986;104:1274.
18. Septon RD. Myopia among optometry students. *Am J Optom Physiol Opt* 1984;61:745–51.
19. Jiang BC, Schatz S, Seger K. Myopic progression and dark focus variation in optometric students during the first academic year. *Clin Exp Optom* 2005;88:153–9.
20. Goss DA, van Veen HG, Rainey BB, Feng B. Ocular components measured by keratometry, phakometry, and ultrasonography in emmetropic and myopic optometry students. *Optom Vis Sci* 1997;74:489–95.
21. Grosvenor T, Scott R. Three-year changes in refraction and its components in youth-onset and early adult-onset myopia. *Optom Vis Sci* 1993;70:677–83.
22. Lanca C, Saw SM. The association between digital screen time and myopia: A systematic review. *Ophthalmic Physiol Opt* 2020;40:216–29.
23. Najafzadeh MJ, Zand A, Shafiei M, et al. Myopia progression during the COVID-19 era: A systematic review and meta-analysis. *Semin Ophthalmol* 2023;38:537–46.
24. Limwattanayingyong J, Amornpetchsathaporn A, Chainakul M, et al. The association between environmental and social factors and myopia: A review of evidence from COVID-19 pandemic. *Front Public Health* 2022;10:918182.
25. Shneor E, Doron R, Ostrin LA, Gordon-Shaag A. The prevalence of refractive errors in college students in Israel. *J Optom* 2022;15:284–92.
26. Ostadimoghaddam H, Fotouhi A, Hashemi H, et al. The prevalence of anisometropia in population base study. *Strabismus* 2012;20:152–7.
27. O'Donoghue L, McClelland JF, Logan NS, et al. Profile of anisometropia and aniso-astigmatism in children: Prevalence and association with age, ocular biometric measures, and refractive status. *Invest Ophthalmol Vis Sci* 2013;54:602–8.
28. Bullimore MA, Conway R, Nakash A. Myopia in optometry students: Family history, age of onset and personality. *Ophthalmic Physiol Opt* 1989;9:284–8.

29. Mirshahi A, Ponto KA, Hoehn R, et al. Myopia and level of education: Results from the Gutenberg Health Study. *Ophthalmology* 2014;121:2047–52.

30. Williams KM, Bertelsen G, Cumberland P, et al. Increasing prevalence of myopia in Europe and the impact of education. *Ophthalmology* 2015;122:1489–97.

31. Logan NS, Davies LN, Mallen EA, Gilmartin B. Ametropia and ocular biometry in a U.K. university student population. *Optom Vis Sci* 2005;82:261–6.

32. Wei S, Sun Y, Li S, et al. Refractive errors in university students in central China: The Anyang University Students Eye Study. *Invest Ophthalmol Vis Sci* 2018;59:4691–700.

33. Kinge B, Midelfart A. Refractive changes among Norwegian university students—A three-year longitudinal study. *Acta Ophthalmol Scand* 1999;77:302–5.

34. 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.

35. O'Neal MR, Connon TR. Refractive error change at the United States Air Force Academy—Class of 1985. *Am J Optom Physiol Opt* 1987;64:344–54.

36. Lin LL, Shih YF, Lee YC, et al. Changes in ocular refraction and its components among medical students—A 5-year longitudinal study. *Optom Vis Sci* 1996;73:495–8.

37. Jacobsen N, Jensen H, Goldschmidt E. Does the level of physical activity in university students influence development and progression of myopia?—A 2-year prospective cohort study. *Invest Ophthalmol Vis Sci* 2008;49:1322–7.

38. Lv L, Zhang Z. Pattern of myopia progression in Chinese medical students: A two-year follow-up study. *Graefes Arch Clin Exp Ophthalmol* 2013;251:163–8.

39. Polling JR, Klaver C, Tideman JW. Myopia progression from wearing first glasses to adult age: The DREAM study. *Br J Ophthalmol* 2022;106:820–4.

40. COMET Group. Myopia stabilization and associated factors among participants in the Correction of Myopia Evaluation Trial (COMET). *Invest Ophthalmol Vis Sci* 2013;54:7871–84.

41. Jorge J, Braga A, Queirós A. Changes in myopia prevalence among first-year university students in 12 years. *Optom Vis Sci* 2016;93:1262–7.

42. Strauss W, Howe N. *Generations: The History of America's Future, 1584 to 2069*. New York: Morrow; 1991.

43. Wu PC, Huang HM, Yu HJ, et al. Epidemiology of myopia. *Asia Pac J Ophthalmol (Phila)* 2016;5:386–93.

44. Pan CW, Zheng YF, Wong TY, et al. Variation in prevalence of myopia between generations of migrant Indians living in Singapore. *Am J Ophthalmol* 2012;154:376–381.e1.

45. Liang YB, Lin Z, Vasudevan B, et al. Generational difference of refractive error in the baseline study of the Beijing Myopia Progression Study. *Br J Ophthalmol* 2013;97:765–9.

46. Guggenheim JA, St Pourcain B, McMahon G, et al. Assumption-free estimation of the genetic contribution to refractive error across childhood. *Mol Vis* 2015;21:621–32.

47. Shapira Y, Mimouni M, Machluf Y, et al. The increasing burden of myopia in Israel among young adults over a generation: Analysis of predisposing factors. *Ophthalmology* 2019;126:1617–26.

48. Mandel Y, Grotto I, El-Yaniv R, et al. Season of birth, natural light, and myopia. *Ophthalmology* 2008;115:686–92.

49. Flitcroft DI. The complex interactions of retinal, optical and environmental factors in myopia aetiology. *Prog Retin Eye Res* 2012;31:622–60.

50. Vongphanit J, Mitchell P, Wang JJ. Prevalence and progression of myopic retinopathy in an older population. *Ophthalmology* 2002;109:704–11.

51. Sankaridurg P, Tahhan N, Kandel H, et al. IMI—Impact of myopia. *Invest Ophthalmol Vis Sci* 2021;62:2.

52. Sanfilippo PG, Chu BS, Bigault O, et al. What is the appropriate age cut-off for cycloplegia in refraction? *Acta Ophthalmol* 2014;92:e458–62.

