Role of tutorial classes and full day schooling on self-reported age of myopia onset: findings in a sample of Argentinian adults

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PURPOSE To investigate the effect of tutorial classes and schooling schedule in childhood on age of myopia onset.

METHODS Refractive data for subjects ≥18 years of age were collected from 8 dispensing opticians or refractive ophthalmologists' offices in Argentina. Age of myopia onset, spherical equivalent (SE), and risk factors were determined using questionnaires. Multiple linear regression models were applied to assess possible factors associated with age of myopia onset or final adult SE.

RESULTS A total of 274 adults (61.3% females) with myopia between −0.50 and −6.00 D were included. Mean age was 36.9 ± 14.5 years. The mean adult SE was −2.95 ± 1.45 D, and the mean age of myopia onset was 14.2 ± 5.4 years. Subjects that attended after-school tutorial classes (β = −2.23; P = 0.005) or a full day schedule in primary school (β = −1.07; P = 0.035) or that spent more time on near work (β = −0.70; P = 0.010) in childhood, had younger age of myopia onset.

CONCLUSIONS In our study cohort, adults that had attended tutorial classes and/or full-day schooling during childhood had younger age of myopia onset. (J AAPOS 2022;26:314.e1-6)

Myopia affects about 30% of the world population.[1] School-age myopia has a multifactorial etiology, and although genetic factors play a role, environmental factors appear to have a major influence on the development of myopia. Increased educational pressures, time spent on near work, and reduced time outdoors have been identified as major risk factors for myopia.[2-4] Participation in after-school tutorial programs or classes has also been identified as a risk factor for myopia.[5,6] In the Myopia Investigation Study in Taipei, children attending tutorial classes 5 or more hours per week had greater risk for incident myopia at 1-year follow-up, whereas children spending 30 minutes or more time outdoors after school had lower risk of incident myopia.[6] In a cross sectional study of Singapore military conscripts (n = 429), tuition lessons in primary school were also associated with myopia.[7] Although the role of tutorial classes on myopia has been investigated previously, the studies were mainly performed in Asian countries,[5-7] and the possible impact of tutorial classes on age of myopia onset seems to be less studied elsewhere.

Younger age of myopia onset is an important predictor of high myopia, which can lead to sight-threatening pathological myopia.[8] About 50% of children with myopia onset at 7 or 8 years of age develop high myopia in adulthood.[9] Myopia progresses more rapidly in children with younger age of myopia onset.[10] Therefore, identification of risk factors for early age of myopia onset is important for helping to curb the development and progression of high myopia. Delay in myopia onset reduces the risk of developing high myopia in adulthood.

The specific role of time of day when children are attending school has not been studied, to our knowledge, to determine the role of timing of outdoor exposure on myopia onset. Animal studies have found that the effects of intense light exposure on myopia development depend on time of day and may be affected by circadian rhythms.[11-14] Brief exposure to intense light in the evening inhibited myopic eye growth in chicks, and simultaneous brief exposure to intense light plus myopic defocus inhibited eye growth in chicks more when it occurred in the morning.[11] Thus, determining the best time of day for children to be outdoors may be important

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for designing outdoor programs to prevent myopia. The aim of the current study was to investigate the effect of attending tutorial classes and schooling schedule, during childhood, on self-reported age of myopia onset in young adults.

Subjects and Methods

Refractive data from eight dispensing opticians or refractive ophthalmologists' offices in Argentina were collected in consecutive myopic subjects aged 18 years or above who attended these offices in July and August 2021. Refractive data were spectacle lens prescriptions. Data collection was performed in several locations, including Salta, Marcos Juarez, Leones, San Pedro, Lobos, Rosario, Buenos Aires, and Mendoza. Those locations are representative of the urban environment (four largest cities in the country) and the rural environment (two largest provinces in the country). The study was conducted in accordance with the tenets of the Declaration of Helsinki, and the study protocol was approved by the ethics committee of the Argentinian Council of Ophthalmology. Verbal consent was obtained from all subjects after the nature of the study was explained. Data were completely anonymized and in full compliance with data protection laws.

Refractive Error and Age of Myopia Onset

Assessment of best-corrected subjective refraction was performed by multiple eye care providers—either qualified opticians who sold spectacles based on ophthalmologists' prescriptions or ophthalmologists who prescribed the spectacles. Spectacle lens data (sphere and cylinder) were included, and the spherical equivalent (SE) was calculated using the standard formula (SE = sphere + ½*cylinder). Myopia was defined as SE of the prescribed glasses equal to −0.75 D or worse. SE for both eyes and age of myopia onset were registered by the prescribing opticians or ophthalmologists using a questionnaire. The SE had to be from the subjects' most recent (current) myopia spectacle lens. Patients with blindness in one eye or other ocular pathologies, such as keratoconus, cataracts, or glaucoma, were excluded, as were subjects with astigmatism of 2.00 D or worse.

Questionnaire for Risks Factors

A questionnaire in Spanish was administered onsite (via Google Docs form) by the treating opticians or ophthalmologists. The questionnaire elicited the following data: age, sex, self-reported age of first spectacle prescription (defined as age of onset of myopia), and environmental risk factors, such as number of years of education, schooling schedule (half day or full day schedule, both in primary and secondary school), tutorial classes (yes, no), time spent on near work (hours per day using computers or performing other near-vision tasks, including reading), time outdoors (hours per day), and time of day spent on studying and outdoors during childhood. Argentina has an obligatory education system, which consists of 6 years of primary school (starting from age 6-7 years) and 6 years of secondary school (from age 12-13 years). In public institutions the schedule includes 4 hours per day in school, in either morning or afternoon, whereas most private schools have a full day of schooling for 8 hours per day.

Statistical Analysis

Prescriptions of myopia-correcting glasses with refractive error up to −6 D SE were eligible for analysis; cases of high myopia in Argentina, where the prevalence of myopia is low,[15] are likely to be of genetic origin, rather than being representative of school-age myopia. SE of right and left eyes was highly correlated (r = 0.81; $P < 0.001$); thus, the analysis used the SE of right eyes only. Using multiple linear regression models, we tested for associations of childhood factors (tutorial classes, years of education, time of day attending school, hours per day of near work and outdoor time), age and sex, with age of myopia onset and adult SE. Age of myopia onset and adult SE were analyzed as continuous variables. All covariates were chosen because of their known relationship to the development of myopia. The results of four models were analyzed for two outcomes: age of myopia onset (models 1 and 2) and adult SE (models 3 and 4). All models included age, sex, number of years of study, whether enrolled in tutorial classes, number of hours per day of near work, number of hours per day outdoors, and time of day for studying. Additionally, school scheduling in primary school was included in models 1 and 3, and school scheduling in secondary school was included in models 2 and 4. Models 1 and 2 were also adjusted for SE, and models 3 and 4 also adjusted for myopia onset. We analyzed correlations and multicollinearity with variance inflation factors to test for significant correlations between the various independent variables included in the model. The results of the regression models are reported as β and P values. In all the analyses, statistical significance was defined as $P < 0.05$. All statistical analyses were carried out with SPSS version 26 (IBM Corp, Armonk, NY).

Results

Data were collected from 342 potential subjects, of whom 274 myopic adults with myopia between −0.75 and −6.00 D were eligible for inclusion: 68 people with high myopia (SE worse than −6.00 D) were excluded; these 68 had lower age of myopia onset (9.14 ± 3.20) than included subjects. Demographic and eye characteristics of included and excluded subjects are provided in Table 1 and eSupplement 1 (available at jaapos.org). Mean age of the 274 subjects was 36.9 ± 14.5 years. The majority were female. Mean SE was −2.95 ± 1.45 D, and mean age of onset was 14.2 ± 5.4 years. There were no significant differences in mean SE or age of myopia onset between sexes. Mean duration of education for these subjects was 15.2 ± 3.2 years.

In childhood, the mean duration of near work per day was 2.6 ± 1.3 hours, and mean duration of time outdoors was 2.7 ± 1.5 hours daily; there were no significant differences in mean duration of time spent on near work or outdoors between sexes. Tutorial classes after school were taken by 24.8% of subjects. The majority spent their time outdoors in the afternoon and spent time studying in the afternoon and at night.

Nearly 60% of the subjects had attended school for 4 hours in the morning, and 20% attended for 4 hours in the afternoon, in both primary and secondary school,

Table 1. Demographic and eye characteristics of included subjects

Characteristic	Subjects[a]	Mean ± SD or %
Years of education	274	15.2 ± 3.2
Hours of reading per day in childhood	231	2.6 ± 1.3
Time spent outdoors per day in childhood, hours	245	2.7 ± 1.5
Tutorial classes after school in childhood		
Yes	68	24.8
No	206	75.2
Time outdoors in childhood		
Morning	30	10.9
Afternoon	229	83.6
Time studying in childhood		
Morning	25	9.1
Afternoon	127	46.4
Night	122	44.5
School scheduling in primary school		
Half-day (4 h), morning	159	58.0
Half-day (4 h), afternoon	59	21.5
Whole day (8 h)	56	20.4
School scheduling in secondary school		
Half-day (4 h), morning	160	58.4
Half-day (4 h), afternoon	53	19.3
Whole day (8 h)	61	22.3

D, diopters; *SD*, standard deviation.
[a]For individual variables the number of subjects may not add up to 274 due to missing data.

whereas only about 20% attended for 8 hours per day. There were no significant differences in duration of time spent on near work for children who went to school either morning, afternoon, or full day. However, subjects who went to school only 4 hours per day spent more time outdoors than did those with a full 8-hour schedule ($P < 0.001$).

Adults who spent the full day at school in childhood had spent less time outdoors than their peers in both primary and secondary school ($P < 0.001$). Adults who attended tutorial classes in childhood spent 2.37 ± 1.49 h outdoors, compared to 2.79 ± 1.49 h for their peers ($P = 0.059$). Among adults who spent the full day at school, those with a younger age of myopia onset or more myopic SE tended to have spent less time outdoors (Figure 1).

The final number of years of study was greater for those who spent a full 8-hour day school ($P < 0.001$). Adults who went to school only 4 hours daily (morning or afternoon) in childhood completed approximately 15 years of study, whereas those who spent full 8-hour days in school had 17 years of education (P values <0.001), but there were

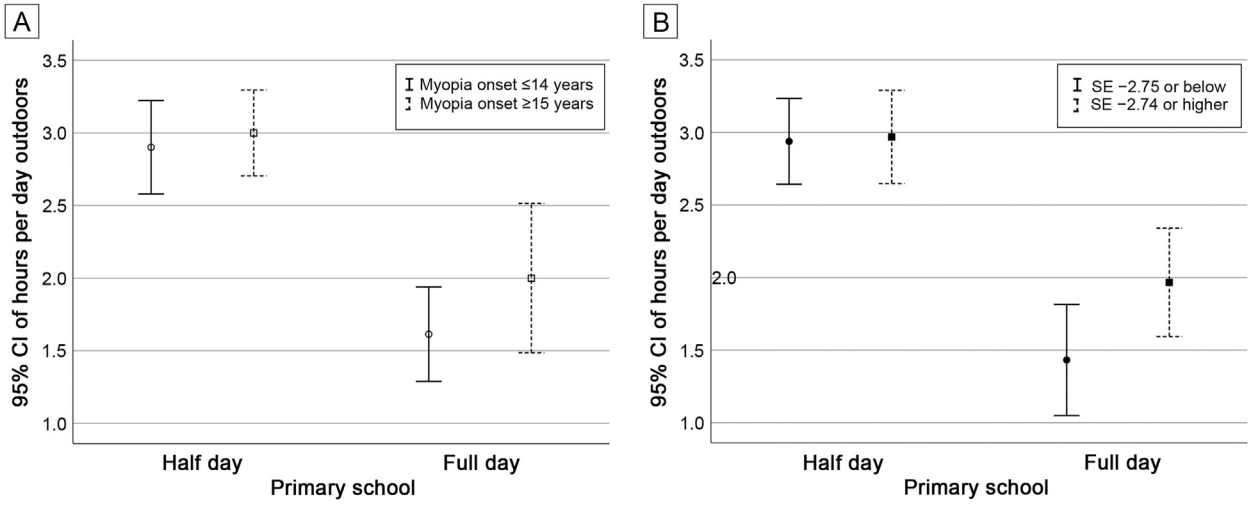

FIG 1. Time spent outdoors stratified by primary school schedule and age of myopia onset (A), or spherical equivalent (SE) (B). Error bars show the 95% confidence intervals (CI) of mean.

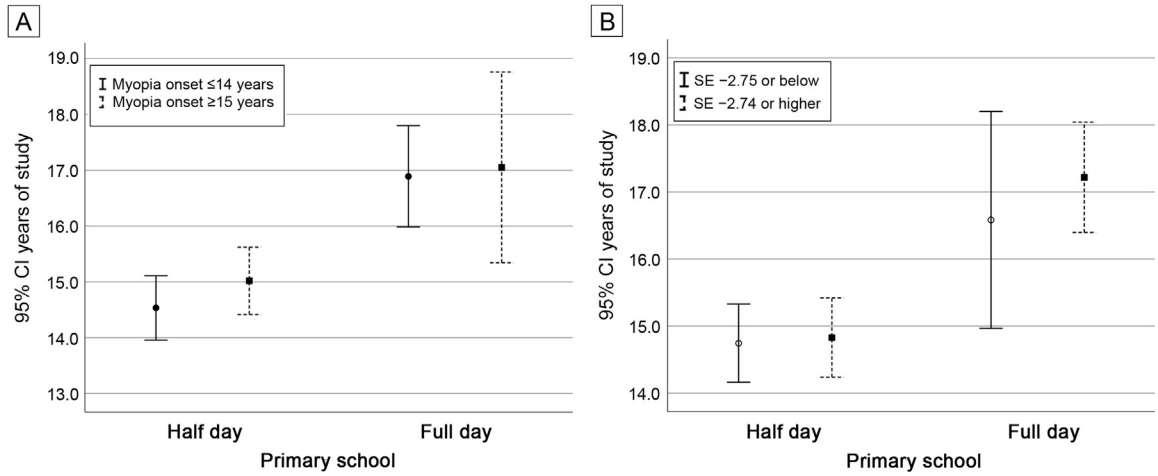

FIG 2. Years of study stratified by primary school schedule and age of myopia onset (A), or SE (B). Error bars show 95% CIs of the mean.

no significant differences in numbers of years of study by tutorial classes. The number of years of study varied little with age of myopia onset or SE (Figure 2).

There were no significant differences in mean adult SE according to time of day attending school or tutorial classes, but the mean age of myopia onset was more than 2 years earlier for subjects who took tutorial classes or went to school all day in primary school, compared with those who went to school only 4 hours daily (Table 2).

Children with later age of onset spent less time on near-work (ANOVA $P < 0.001$). There were no significant differences in mean SE or age of myopia onset, according to whether subjects studied during morning, afternoon or night, or whether they spent time outdoors in the morning or afternoon.

The multiple linear regression analysis for age of onset in adulthood is provided in Table 3. Adults who attended after-school tutorial classes ($P = 0.005$) or spent full days in school ($P = 0.035$) or who spent more time on near work ($P = 0.010$) in childhood had younger age of myopia onset. The age of myopia onset decreased by 0.7 years with each one-hour increase in near work per day, and it decreased by 0.4 years with each 1 D decrease (more negative, i.e., more myopic) in SE. Age of myopia onset was the only risk factor associated with adult SE ($P < 0.001$), there being a decrease in adult SE by 0.09 D with each 1-year decrease in age of myopia onset.

Discussion

In this study cohort, adults who had attended after-school tutorial classes or full-day schooling or who had spent more time on near work in childhood had a younger self-reported age of myopia onset. These associations persisted after adjusting for age and sex in the linear regression analysis. An association between educational systems and myopia has been identified in several studies in Singapore and Israel.[7,16-18] The results from those studies showed that increased number of hours reading and better education were associated with myopia. In our study we found a much younger age of myopia onset in adults that attended full-day school in childhood compared with adults attending for only half-days (4 hours). The Argentine school system allowed us to compare the effects of half-day with those of full-day scheduling, showing that 8 hours per day of schooling in childhood is a risk factor for myopia onset earlier in childhood. Previous studies have shown that educational

Table 2. Tutorial classes and school scheduling and the association with age of myopia onset and spherical equivalent (N = 274)

	No.	Age of onset, years	*P* value	No.	SE (D)	*P* value
Tutorial classes						
No	198	14.66 ± 5.23	0.008	206	−2.96 ± 1.44	0.92
Yes	68	12.65 ± 5.60		68	−2.93 ± 1.50	
School scheduling in primary school						
Half-day (4 hours)	211	14.66 ± 5.41	0.002	218	−3.02 ± 1.48	0.13
Whole day (8 hours)	55	12.16 ± 4.82		56	−2.69 ± 1.29	
School scheduling in secondary school						
Half-day (4 hours)	206	14.45 ± 5.23	0.081	213	−3.03 ± 1.49	0.1
Whole day (8 hours)	60	13.10 ± 5.81		61	−2.68 ± 1.28	

Table 3. Multiple linear regression analysis for age of myopia onset

Study parameter	β	P value
Age	−0.03	0.28[a]
Sex	−0.32	0.65[a]
SE	0.40[b]	0.001[a]
School scheduling in primary school	−1.07	0.035[a]
School scheduling in secondary school	−0.09	0.85[c]
Years of study	0.13	0.24[a]
Tutorial classes	−2.23	0.005[a]
Hours per day of near work	−0.70[d]	0.010[a]
Hours per day outdoors	0.21	0.39[a]
Studying at night or afternoon	−0.38	0.48[a]

SE, spherical equivalent.
[a]Model 1 included age, sex, SE, school scheduling in primary school (full vs half days), years of study, tutorial classes, hours per day of near work, hours per day outdoors, and studying at night or afternoon.
[b]For each 1 D decrease in SE (more negative, ie, more myopic), there was a decrease in age of myopia onset by 0.4 years.
[c]Model 2 included age, sex, SE, school scheduling in secondary school, years of study, tutorial classes, hours per day of near work, hours per day outdoors and studying at night or afternoon.
[d]For each 1 hour increase in reading per day, there was a decrease in age of myopia onset by 0.7 years.

systems in which studies involve intense reading and other near work (for example, the ultra-Orthodox educational system of Israel) play an important role in the development of myopia.[16,19]

Our results indicate that near work can promote the onset of myopia, which is consistent with the study of Li and colleagues[20] showing that children with hyperopic refraction should be monitored before primary school, and a hyperopia reserve should be maintained to prevent the onset of myopia.

We also found that adults who obtained full-time schooling were more likely to complete more years of education. Previous studies in various populations have shown that more years of education is associated with increased risk of myopia development.[18,21-24] For example, one study found that countries with high prevalence of myopia, such as China, Taiwan, Singapore, Japan and South Korea, had high educational performance and high engagement in after-school tutorials.[25] The authors concluded that after-school tutorials might serve as a marker for educational environments that impose higher educational loads.

In the present study, the only childhood risk factor associated with final SE in adulthood was age of myopia onset. Children with early onset experience more years of myopia progression until myopia stabilizes in early adulthood. Although attending primary school whole rather than half days, tutoring and near work hours were associated with age of onset, there were no such associations with final refractive error after adjusting for age of onset. This suggests that in this cohort, environmental risk factors may primarily impact age of onset rather than the rate of progression after onset. Children who experience myopia onset at earlier ages are at higher risk of myopia progression[26,27]—and if as a result they develop high myopia in adolescence or adulthood, their risk of developing blinding conditions, such as myopic macular degeneration, glaucoma, and cataract will be significantly increased. Strategies to curb early myopia onset are important to prevent the progression to high myopia.

We did not find significant differences in time spent on near work when stratifying our cohort by tutorial classes and school scheduling. However, adults who reported spending more time on near work in childhood had myopia onset at a younger age. We also found significant differences in time spent outdoors by different schooling groups. Adults who had attended full-day school or tutorial classes also had spent less time outdoors during childhood. Children attending tutorial classes and full-day school might have fewer opportunities to spend time outdoors, because tutorial classes often last until late evening. Outdoor programs in school during the day, when intense light is available, could be beneficial for preventing myopia in those children who are under high educational pressure. Increased time spent outdoors is associated with reduced risk of myopia, and outdoor school programs have been shown to be beneficial in the prevention of myopia in children aged 5-6 years.[14,28-31] The overall prevalence of high myopia in Argentina is low; this may be in part because children in Argentina spend almost 4 hours per day outdoors,[15,32] with a resulting delay in myopia onset.

We did not find significant differences in age of myopia onset according to whether the subjects were studying at home during morning, afternoon, or night, or whether their time spent outdoors was in morning or afternoon. The effect of time of day when attending school and the potential ocular effects of intense light exposures at different times of the day thus remains an unanswered question, requiring further research. In a study of young adults given 30 minutes of light-therapy in the morning for 1week, significant choroidal thickening was observed[31]; however, in another study of young adults exposed to ambient light of 1000 lux at night before sleep, subfoveal choroidal thickness was reduced.[14] These results may indicate that circadian rhythms are influenced by illumination conditions that mediate refractive changes and myopia development. However, the exact mechanisms underlying choroidal changes and refractive changes are not known.

This study has several strengths. The educational system in Argentina allowed us to compare participants exposed to different educational pressures and to include measures of final adulthood SE. However, there are also several limitations. First, this was a cross-sectional and retrospective study, and follow-up studies with longitudinal data are necessary. Second, although the accommodation effect of cycloplegia is smaller in adults than in children, some

outcomes might have been affected by the fact that SE was not necessarily measured with cycloplegia. Third, although questions regarding schooling schedules may have been accurately answered by the participants, the questions on how much time they had spent on near work and being outdoors in childhood are likely to be less accurate after so many years, and thus recall bias cannot be excluded. Fourth, our subjects' ethnicity was not available, and further studies are necessary to assess whether ethnicity might play a role in the age of myopia onset.

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